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Università degli Studi Niccolò Cusano - Telematica Roma

Course	**General Physics I**
Level and Degree Program	Bachelor's in Industrial Engineering (L-9) and Civil Engineering (L-7)
Academic Discipline (SSD)	FIS/01
Academic Year	2024-2025
Year of Study	**1**
Total Credits	**9**
Prerequisites	**Geometry, Calculus I**
Instructor	**Pietro Oliva** **Assistant: Dr. Cristina Martellini** *Platform Nickname: oliva.pietro* *Platform Nickname: cristina.martellini* *Degree Program in Engineering* *Email: pietro.oliva@unicusano.it (for internal communications, theses, internships, and administrative issues only). For course-related questions, use the platform messaging system.* *Office hours: Check the videoconference schedule on the University website.*
Course Description	The course provides foundational knowledge in Mechanics and Thermodynamics essential for tackling various engineering topics. It begins with simple scenarios, covering kinematics and dynamics under the point mass approximation, fundamental principles like mechanical energy conservation, and the work-energy theorem. It then extends to the mechanics of extended systems and rigid bodies. Finally, it introduces the basic principles of thermodynamics, with optional coverage of Fluid Dynamics and Optics depending on active e-tivities. The course emphasizes both theoretical and practical aspects. The theoretical component rigorously introduces models, supported by comprehensive mathematical treatments and a wide array of examples. The practical component includes numerous exercises, online simulations, and in-person/streaming experiments conducted in the Physics Teaching Lab. Course e-tivities include Original Problems and Self-Assessment Tests, aimed at deepening understanding and contributing to the final grade. The primary goal is to equip students with analytical and problem-solving skills applicable to real-world engineering contexts.
Learning Objectives	The General Physics 1 course aims to achieve the following learning outcomes aligned with the specific objectives of the degree program: 1.Kinematics of point masses: Study uniform and non-uniform motion, motion in a plane, harmonic motion, damped motion, and circular motion. 2.Dynamics of point masses: Classical mechanics forces, friction forces, static equilibrium, work, and energy. 3.Kinematics and dynamics of complex systems: Analysis of systems of particles and rigid bodies. 4.Thermodynamics principles: Understanding basic thermodynamic principles and key thermodynamic cycles. 5.Optional modules: Fluid Dynamics and Optics for specialized curricula (Biomedical, Agro-Industrial, and Electronics).
Knowledge Prerequisites	To enroll in General Physics I, students **must** have passed Calculus I and Geometry. No exceptions will be made for exam eligibility without these prerequisites. For successful course participation, a strong grasp of the following topics is essential: • Differential and integral calculus • Vector and matrix algebra • Trigonometry • Elementary algebra Students are encouraged to review the Pre-Course lectures. If difficulties arise, immediate revision of Analysis and Geometry topics is advised. Specifically, students should master: • Basic algebraic and geometric theorems • Trigonometry • First- and second-degree equations and inequalities • Exponentials and logarithms • Real-valued functions • First- and second-order non-homogeneous linear differential equations with non-constant parameters • 1D limits, derivatives, and integrals • Matrix manipulation (eigenvalues and eigenvectors)

Expected Learning Outcomes	By the end of the course, students will demonstrate the following abilities: **[Knowledge and Understanding]** • Understand terminology related to mechanics of point masses, extended systems, rigid bodies, thermodynamics, fluid dynamics, and optics. • Master fundamental laws governing the dynamics and statics of bodies and thermodynamic transformations. • Understand basic principles of fluid dynamics and optics. **[Application of Knowledge]** • Identify specific solutions to problems in kinematics, statics, dynamics, and thermodynamics. • Understand classical physics theories. • Derive conceptual models from real-world problems. **[Critical Thinking]** • Solve analytical and numerical problems related to mechanics (point masses, extended systems, and rigid bodies) in both equilibrium and non-equilibrium configurations, as well as thermodynamic transformations. **[Communication Skills]** • Develop precise, rigorous, and comprehensible scientific language to clearly and comprehensively communicate acquired knowledge and techniques. **[Learning Skills]** • Apply acquired knowledge to solve original problems in mechanics and thermodynamics. • Search for and find in literature the right answers (or the right questions) to original problems encountered in professional settings.
Course Structure	**Teaching and Learning Activities** The course includes teaching activities and learning activities. Teaching activities consist of pre-recorded and/or synchronous web conference lectures. Learning activities involve independent study of materials and exercises provided by the instructor, as well as self-study required to complete self-assessment tests and e-tivities. The exercises in the modules help quickly verify understanding of the subject. Students can submit their completed exercises via the platform messaging system to clarify unresolved doubts or difficulties. E-tivities must be completed independently and submitted as clear and complete solutions to the instructor via private platform messaging. Scanned PDFs are recommended for submission. **Study Schedule** The course is designed to be completed in approximately two months, requiring a weekly commitment of at least 25 hours. However, if this pace cannot be maintained, two months may not be sufficient for adequate preparation. The course is self-paced and suitable for working students. It is recommended to plan the final exam at least two months after starting the course. **Virtual Classroom** The course features a virtual classroom. All communications with the instructor regarding course topics should take place in the virtual classroom forum. **Workload** The total workload for this course is 220 hours, divided as follows: • 25 hours for reviewing video materials • 175 hours for independent study • 20 hours for completing e-tivities

Course Contents

Pre-course — Basic Mathematics Refresher (Optional) Strongly recommended for students with gaps in mathematics.

Module 01 — Kinematics of a Material Point
[5 recorded lessons; 3 self-assessment tests; 1 graded test. Study load: 23 hours – Week 1]
Educational Activities:
The module includes 3.25 hours of pre-recorded lectures and quick tests related to various topics. Considering the time required for review and possible synchronous lessons, a minimum of 15 hours is expected for lectures and at least 7 hours for exercises.

Learning Outcomes:
By the end of the module, students will be able to:
• Understand and calculate the fundamental quantities of kinematics.
• Analyze and derive the main types of motion for a material point, both linear and curvilinear.
• Recognize basic motions of a material point approximation, such as free fall, simple harmonic motion, exponentially damped motion, and circular motions.
• Derive all kinematic properties of a point from its position-time function.
• Reconstruct a material point's position-time function from its acceleration, using initial conditions.

Learning Objectives:
This module covers the fundamental quantities of kinematics and introduces the material point approximation. Basic concepts of mathematical analysis and algebra are revisited to provide tools for deriving key motion equations, from simple one-dimensional uniform rectilinear motion to more complex cases of varied three-dimensional motion. Both direct calculation (deriving all kinematic quantities from the position-time function) and inverse problems (deriving position-time functions from acceleration under different conditions) are introduced.

Module 02 — Dynamics of a Material Point
[10 recorded lessons; 3 self-assessment tests. Study load: 47 hours – Weeks 2-3]
Educational Activities:
The module includes 6.7 hours of pre-recorded lectures and related tests. Considering review time and possible synchronous lessons, at least 35 hours are required for lectures and 5 hours for exercises.

Learning Outcomes:
By the end of the module, students will be able to:
• Understand various dynamics quantities.
• Apply Newton's laws to a wide range of fundamental problems in the material point approximation.
• Connect the dynamic problem of causes to the kinematic problem of effects.
• Solve Newton's second law for common natural forces (gravity, elasticity, friction, tension).
• Recognize and evaluate static and dynamic equilibrium situations.
• Apply classical mechanics models (inclined plane, simple pendulum, centripetal force systems).

Learning Objectives:
This module introduces the concept of force and explains Newton's Second Law within the material point approximation. Methods for analyzing static and dynamic equilibrium, constraint reactions, and resultant forces are illustrated. Newton's equation is applied to primary forces (gravity, elastic, friction, tension). Paradigmatic models of classical mechanics are presented, extending beyond the material point approximation for more complex scenarios.

Module 03 — ENERGY: Work, Potential Energy, Kinetic Energy
[5 recorded lessons; 1 self-assessment test. Study load: 29.5 hours – Week 4]
Educational Activities:
The module includes 4.2 hours of pre-recorded lectures and related exercises. A total of 20 hours is recommended for lectures and approximately 4 hours for exercises.

Learning Outcomes:
By the end of the module, students will be able to:
• Calculate work done by a force along a displacement.
• Relate work calculations to kinetic energy changes.
• Distinguish between conservative and non-conservative forces.
• Calculate potential energy for common conservative forces.
• Use the mechanical energy conservation theorem to solve dynamic problems under both conservative and dissipative forces.

Learning Objectives:
This module introduces and develops the concepts of work and energy. The kinetic energy theorem and its application to work calculation are demonstrated. Conservative and non-conservative forces are rigorously defined with practical examples. Potential energy concepts are introduced and applied to conservative forces (gravity, elastic forces). The mechanical energy conservation theorem is demonstrated, and its use in equilibrium and non-equilibrium dynamics, under conservative and dissipative forces, is illustrated.

Module 04 — Dynamics of Extended Systems and Rigid Bodies
[3 recorded lessons; 2 self-assessment tests. Study load: 23.7 hours – Week 5]
Educational Activities:
The module includes 3.2 hours of pre-recorded lectures and related exercises. A total of 18 hours is recommended for lectures and at least 3 hours for exercises.

Learning Outcomes:
By the end of the module, students will be able to:
• Extend the concepts learned in material point approximation to complex systems and rigid bodies.
• Calculate dynamic quantities (angular momentum, torque) for complex systems and rigid bodies.
• Decompose the motion of a complex system into translational and rotational components.
• Apply the center of mass and angular momentum theorems, Koenig's theorems, and mechanical energy conservation to solve dynamics problems.
• Use rigid body density concepts to calculate the center of mass.
• Calculate moments of inertia for general and basic geometries and apply them to rotational dynamics.
• Use the parallel axis theorem for simplifying rigid body dynamics problems.

Learning Objectives:
This module moves beyond single material point approximation, introducing kinematics and dynamics of complex systems and rigid bodies. Quantities such as angular momentum and torque are introduced mathematically and practically, starting with material points and expanding to complex cases. Fundamental theorems for complex systems and rigid bodies (angular momentum, center of mass, Koenig's, mechanical energy) are presented rigorously.

Module 05 — Introduction to Thermodynamics
[7 recorded lessons; 1 self-assessment test. Study load: 33.3 hours – Week 6]
Educational Activities:
The module includes 4.75 hours of pre-recorded lectures and related exercises. A total of 25 hours is recommended for lectures and at least 4 hours for exercises.

Learning Outcomes:
By the end of the module, students will be able to:
• Analyze and identify thermodynamic systems under the first law of thermodynamics.
• Use main thermodynamic variables in the study of transformations, especially for ideal gases.
• Calculate key quantities (work, heat, and thermodynamic variables) during thermodynamic transformations (isobaric, isochoric, isothermal, adiabatic).

Learning Objectives:
Basic thermodynamics concepts are introduced. Thermodynamic systems, transformations, and variables are explained, followed by work, heat, and energy concepts from a thermodynamic perspective. The first law of thermodynamics is demonstrated, especially for ideal gas approximations. Detailed analysis of primary transformations (isobaric, isochoric, isothermal, adiabatic) is provided.

Module E — E-tivity
[Study load: 20 hours – 4 days]
Educational Activities:
No lectures are provided. Learning is pursued through independent study and activities proposed by the instructor.

Learning Outcomes:
By the end of the module, students will be able to:
- Assess their understanding of various course topics independently.
- Determine appropriate problem-solving methodologies.
- Utilize theoretical material and exercises effectively.
- Complete instructor-assigned tasks with scientific clarity and comprehensive analytical/numerical results.

Learning Objectives:
This module involves self-assessment tests and solving complex problems (E-tivity) with detailed guidelines. Tasks cover all course topics and contribute to final exam evaluation.

Materials	Although the course materials provided by the instructor are considered sufficient, a fundamental and complex course like General Physics 1 requires a serious evaluation of acquiring essential textbooks. These should be a staple in the library of any respectable engineer. It is therefore recommended to add at least one of the following texts, all deemed equally optimal by the instructor for exam preparation: • Daniele Sette, Adriano Alippi, Andrea Bettucci, Lezioni di Fisica 1 • David Halliday, Robert Resnick, Jearl Walker, Fondamenti di Fisica - Mechanics, Waves, Thermodynamics, Electromagnetism, Optics (8th Italian edition, Ambrosiana Publishing, exclusively distributed by Zanichelli) • Fisica Generale - Meccanica e Termodinamica (2nd edition) by Focardi, Massa, Uguzzoni, Villa For foreign students, ERASMUS, and English-speaking students: Halliday, Resnick — Fundamentals of Physics, 10th edition.
Evaluation Method	**Final Grade** The assessment of Learning Outcomes is conducted through the evaluation of E-tivities and the final examination. The final grade is the sum of the scores obtained in these components. A minimum of 18 points (18/30) is required to pass without exception. **E-tivity Evaluation** E-tivities assess all listed Learning Outcomes, particularly those related to learning skills. The contribution of E-tivities to the final grade is capped at a maximum of 2 points. **Final Exam Evaluation** The final exam, which can be taken online, off-campus, or on-site (Rome), consists of a written test with exercises covering the syllabus. The exam duration is 90 minutes, and solutions must strictly adhere to the proposed questions. Clear exposition, both graphically and methodologically, along with explanatory comments to justify steps, will be valuable for assessment. The use of scientific calculators (including programmable ones) is allowed, but other electronic devices (e.g., computers, tablets, smartphones) or any tools enabling internet access are strictly prohibited. Maintaining academic integrity is a point of honor for preserving the intrinsic value of your degree.
Criteria for the Final Thesis Assignment	The assignment of the final thesis will be based on an interview with the instructor where the student can express their specific interests regarding topics they wish to explore in depth. There are no restrictions on requesting a thesis, and no specific mark average requirement is imposed for eligibility.
Reduced Program	Students who, due to recognition of a related exam taken in a prior academic career, need to take the General Physics 1 exam are advised to contact the instructor, providing the syllabus of the previously completed exam. This will allow the instructor to determine the modules required for completing the reduced program (< 9 ECTS).