FISICA I Cp - I

FIS/01 - 9 CFU - 2° Semester

Teaching Staff

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LEARNING OBJECTIVES

The course aims at providing basic knowlegde of classical mechanics and thermodynamics topics

included in the Course Content (see below) as well as the capability to apply the Scientific Method and mathematical models and concepts to the resolution of real and concrete problems.

In particular, the course has the objectives to provide pupils with the following knowledge and abilities.

Knowledge and understanding abilities

Knowledge of the main phenomenological aspects related to classical mechanics and thermodynamics and understanding of their physical implications and their mathematical description within a general modeling and logical-deductive apparatus.

Applying knowledge and understanding ability

Ability to recognize the main physical laws that govern a mechanic or thermodynamic phenomenon, and to apply them to solve problems and exercises at different levels of complexity and therefore of

approximation, with the use of appropriate analytical and numerical techniques.

Ability of making judgements

Evaluation of the order of magnitude of the variables that describe a mechanic or thermodynamic phenomenon. Evaluation of the relevance of a physical law (axiom, principle of conservation, universal

law, theorem, law in global/integral or local/differential form and its generality, properties of materials, etc.).

Communication skills

Capability to expose scientific concepts in a proper and inambiguous manner, at various levels.

Learning skills

Application to Physics of theoretical/mathematical techniques.

COURSE STRUCTURE

Prerequisites

Although no prerequisites are officially imposed, it is extremely useful that students master the subjects of elementary mathematics (algebra, geometry, trigonometry, analytic geometry) and have knowledge of those of differential and integral calculus.

Attendance to lectures

Although it is not mandatory, attendance to classroom lectures is strongly recommended.

Didactic activity

Didactic activity consists of classroom lectures and exercises. Exercises can be both assignments of the teacher for the homework or driven by the teacher - or by tutors, if available - in the classroom. During each lesson, students will always be left with questions, curiosities and comments.The teacher-student interaction will be one of the fundamental tools during classroom exercises.

Didactic material

A collection of exercises, many of which were assigned during the written exam sessions, is available on the web page of the course in the Studium portal (http://studium.unict.it), inside the section called

Documenti and on the teacher’s website (https://nanostar.jimdo.com/).

Learning verification

The final exam consists of a written test followed by an oral exam. Booking on the Student Portal platform is mandatory for admission to the written test. Admission to the oral exam is subject to passing the written test. There is no way to pass the exam without taking all the tests. After the written test and

before the oral one, a public discussion of the written test exercises is carried out by the teacher in order to solicit a process of self-evaluation of the written test by the students. The results of the written tests are published on STUDIUM (http://studium.unict.it) and/or on the teacher's personal website (https://nanostar.jimdo.com/).

- Written exam: The written test must be taken in one of the appeals imposed by the calendar, after student booking. Type: resolution, clearly justified and commented on, of four problems that span over all the topics of the course program, whose level of difficulty is similar to the exercises carried out in the classroom. Duration: 180 minutes. Evaluation: up to 7.5 points for every weel-done problem well. The written test is considered passed if a grade of not less than 18/30 is achieved. Students are admitted to the oral test only by passing the written test.

NOTES for the written tests: a) During the written test the use of the pen, pencil, calculator, ruler, compass, consultation of books, notes and forms is allowed; b) during the written test it is not allowed to consult electronic devices beyond the calculator and consultation between colleagues is not allowed (under penalty of withdrawal of the test); c) who, having passed a written test comes to a second written test loses the result of the first test (even if he decides to withdraw from the second one).

- Oral exam The oral exam is taken after the written exam and in any case by the same time as the written exam. Exceptionally, it may be allowed to take the oral exam during the next call, but always within the same exam session. The oral exam can be repeated a second time, without having to re-do the written test, but always within the same exam session. The oral exam focuses on various topics of the course program (as reported in the Syllabus) and typically lasts 45 minutes. The evaluation elements of the oral test will be: relevance of the answers with respect to the questions, quality of the contents, ability to connect with other topics covered by the program, ability to report examples, the property of technical language and the overall expressive capacity of the student. Moreover, during the oral test the demonstration of theorems and important results included in the program can be requested with numerical evaluations of the order of magnitude of the physical quantities that are involved in a given phenomenon.

At the end of the oral exam, the teacher, in consideration of the results of the written test and the oral exam, establishes a global grade for the exam that will be considered passed with an overall grade of at least 18/30.

There are no ongoing tests

Dates of the exams

Check the following web pages

http://portalestudente.unict.it

http://www.dieei.unict.it/corsi/l-8-ele/esami

and the notices on the course page on the Studium portal (http://studium.unict.it) or teacher’s website (https://nanostar.jimdo.com/) for details on the time and place of the exams and any changes.

Examples of asked questions and exercises

The questions asked during the oral exam will be related exactly to the topics of the program. For example:

"enunciate and demonstrate the principle of conservation of mechanical energy"

"present and discuss the 3 Newton's laws of mechanics"

"enunciate and demonstrate the principle of momentum conservation"

“definition of conservative force”

“discuss the dynamics of simple pendulum”

"discuss the dymanics of a rigid body: degrees of freedom, equations of motions and conservation

laws"

"tell me about the thermodynamic equilibrium and the principle of thermal equilibrium"

"say aloud the enunciates of the second principle of thermodinamycs and demonstrate their

equivalence"

"evaluate the internal energy of monoatomic gas and that of a biatomic one"

“definition of entropy in a thermodynamic transformation”

“demonstrate and comment the Bernoulli thorem”

“description of the gravitation law”

etc.

During the oral exam it may be necessary to demonstrate theorems and important results included in the program with numerical evaluations of the order of magnitude of the physical quantities involved in a given phenomenon.

A collection of exercises, many of which were assigned during the written exam sessions, is available on the course page on the Studium portal (http://studium.unict.it), in the Documents section.

DETAILED COURSE CONTENT

PRELIMINARY CONCEPTS

A) Physics and reality. The experimental method.

B) The units of measurement. The international system. Dimensional calculations.

C) Vector algebra.

C.1) Scalar and vector quantities.

C.2) Property of vectors: sum rule, vector decomposition, invariance property.

C.3) Products between vectors: scalar product, vector product, moment of a vector with respect to a point.

C.4) Derivative of a vector. Derivative of a versor. Intrinsic writing of the derivative.

C.5) Vector integration. Line integral.

C.6) Functions of more variables: partial derivatives, gradient of a scalar function

MECHANICS

1) Kinematics of the material point.

1.1) Introduction.

1.2) One-dimensional motion.

1.3) Velocity in one-dimensional motion. Uniform straight motion.

1.4) Acceleration in rectilinear motion. Uniformly accelerated rectilinear motion.

1.5) Vertical motion of a body.

1.6) Simple harmonic motion.

1.7) Two-dimensional motion. Position and velocity. Cartesian components. Polar components.

1.8) Acceleration in two-dimensional motion. Cartesian components. Polar components.

1.9) Circular motion.

1.10) Parabolic motion of bodies.

2) Dynamics of the material point.

2.1) Principle of inertia. Introduction to the concept of force.

2.2) Newton's laws.

2.3) Impulse.

2.4) Resultant of the forces. Equilibrium. Reactions.

2.5) Dynamic action of force.

2.6) Gravitational force and weight.

2.7) Forces of sliding friction.

2.8) Inclined plane.

2.9) Elastic force.

2.10) Viscous friction force.

2.11) Centripetal forces. Curve on a flat road. Elevated curves.

2.12) Simple pendulum.

2.13) Tension. Atwood machine.

2.14) Work. Power. Kinetic energy.

2.15) Work of the gravitational force. Work of a constant force.

2.16) Work of an elastic force.

2.17) Work of a sliding friction force.

2.18) Conservative forces. Potential energy.

2.19) Conservation of mechanical energy. Energy conservation for gravitational and elastic forces. Conservation of energy in the simple pendulum. No-conservation of energy.

2.20) Relationship between potential energy and force.

2.21) Angular momentum. Moment of the force. Angular momentum theorem.

2.22) Central forces.

3) Relative motion.

3.1) Reference systems. Relative velocity and acceleration. Relative velocity theorem. Relative acceleration Theorem of the relative acceleration.

3.2) Inertial reference systems. Galilean relativity.

3.3) Uniform rotational motion.

5) Gravitation.

5.1) Gravitational force.

5.2) Inertial mass and gravitational mass.

5.3) Gravitational field.

5.4) Gravitational potential energy. Gravitational potential. Energy plots.

5.5) Gauss theorem.

5.6) Determination of the trajectory. Equation of motion. Angular momentum. Power. Energy plots.

6) Dynamic and static of the rigid body.

6.1) Definition of rigid body. Preliminary properties.

6.2) Motion of a rigid body.

6.3) Continuous body. Density. Center of mass. Center of mass and weight force.

6.4) Rigid rotations around a fixed axis in an inertial reference system. Calculation of the angular momentum. Moment of inertia. Equations of motion. Calculation of kinetic energy and work.

6.5) Moment of inertia.

6.6) Huygens-Steiner theorem. Huygens-Steiner theorem and Konig theorem.

6.7) Pure rolling motion. Energy conservation and rolling friction.

6.8) Angular impulse. Moment of the impulse.

6.9) Conservation laws in the motion of a rigid body.

6.10) Impacts between material points and rigid bodies or between rigid bodies.

6.11) Statics of the rigid body. The problem of scale.

7) Elastic properties of solids.

7.1) Traction and compression.

7.2) Plastic deformation. Break.

7.3) Scrolling.

7.4) Pressure. Uniform compression.

8) Oscillations and waves.

8.1) Properties of the differential equation of the harmonic oscillator.

8.2) Energy of the harmonic oscillator.

8.3) Harmonic oscillator damped by a constant friction force.

8.4) Harmonic oscillator damped by a viscous force. Strong damping, critical damping, weak damping.

8.5) Forced harmonic oscillator.

8.6) Fourier analysis.

8.7) Introduction to wave phenomena.

8.8) Elastic waves in a solid bar.

8.9) Waves in a tight rope.

8.10) Elastic properties of gases. Propagation of waves in gases.

THERMODYNAMICS

9) First law of thermodynamics.

9.1) Thermodynamic systems and states.

9.2) Thermodynamic equilibrium. Principle of thermal equilibrium.

9.3) Definition of temperature. Thermometers. Thermometric scales.

9.4) Adiabatic systems. Joule experiments. Heat.

9.5) First law of thermodynamics. Internal energy.

9.6) Thermodynamic transformations. Work and heat. Adiabatic transformations. Reversible and irreversible transformations.

9.7) Calorimetry. Measurement of specific heats. Specific heats of solids.

9.8) Isothermal processes. Phase changes.

9.9) Thermal expansion of solids and liquids.

10) Ideal gases.

10.1) Ideal sas laws. Boyle's isothermal law. Isobar law of Volta-Gay Lussac. Isochoric law of Volta Gay-Lussac. Avogadro's law. State equation of the ideal gas.

10.2) Transformations of a gas. Work.

10.3) Heat. Specific heats.

10.4) Internal energy of an ideal gas. Mayer's law.

10.5) Study of some transformations. Adiabatic transformations. Isothermal transformations. Isochores transformations. Isobar transformations.

10.6) Cyclic transformations. Carnot cycle. Refrigeration cycles.

10.7) Kinetic theory of gases. Pressure calculation. Equipartition energy. Dynamic meaning of temperature and heat.

11) Second law of thermodynamics.

11.1) Statements of the second law of thermodynamics.

11.2) Reversibility and irreversibility.

11.3) Carnot's theorem. Study of the maximum efficiency.

11.4) Absolute thermodynamic temperature. Definition of the Kelvin unit. Absolute zero.

11.5) Clausius theorem.

11.6) The entropy status function.

11.7) The principle of increasing entropy.

11.8) Calculations of variations of entropy. Adiabatic transformations. Heat exchanges with sources. Heat exchanges between two bodies. Phase changes. Friction heating.

11.9) Ideal gas entropy. Adiabatic transformations.

11.10) Unusable energy. Free expansion of a gas. Heat transfer from a hot source to a cold one. Irreversible machine that works between two sources.

11.11) Thermodynamic conclusions on entropy. Entropy and probability.

11.12) Basics on the third principle of thermodynamics.

12) Real gases.

12.1) Real gases. Van der Waals equation.

12.2) pV Diagrams. PT diagrams

TEXTBOOK INFORMATION

1) P. Mazzoldi, M. Nigro e C. Voci, *Fisica – Volume I, Seconda Edizione* (EdiSES, Napoli, 2003): Theory

2) P. Mazzoldi, A. Saggion, C. Voci, Problemi di Fisica Generale-Meccanica, Termodinamica (Edizioni Libreria Cortina Padova 1996): Exercises

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