

**COURSE DATA****Data Subject**

<b>Code</b>	34243
<b>Name</b>	Oscillations and waves
<b>Cycle</b>	Grade
<b>ECTS Credits</b>	4.5
<b>Academic year</b>	2020 - 2021

**Study (s)**

<b>Degree</b>	<b>Center</b>	<b>Acad. year</b>	<b>Period</b>
1105 - Degree in Physics	Faculty of Physics	2	Second term

**Subject-matter**

<b>Degree</b>	<b>Subject-matter</b>	<b>Character</b>
1105 - Degree in Physics	6 - Mechanics and waves	Obligatory

**Coordination**

<b>Name</b>	<b>Department</b>
FONT RODA, JOSE ANTONIO	16 - Astronomy and Astrophysics
NOGUERA PUCHOL, SANTIAGO	185 - Theoretical Physics

**SUMMARY**

The subject "Oscillations and Waves" is a four-month course of the second year of the Degree in physics, belonging to the matter "Mechanics and Waves" and has allocated 4.5 credits (38 hours of theoretical and practical classes and 7 h supervised work sessions for problem solving in small groups).

The descriptors proposed in the document Curriculum Degree in Physics established to address the following topics: simple oscillator, damped and forced resonance, small oscillations and normal modes, wave equation and solutions, boundary conditions, standing waves, interfaces packages.

Basic objectives in relation to other subjects of the degree

The subject "Physical II" matter "Physics" first course contains aspects of the oscillations and waves to a more basic level and conceptual, focusing on the basics, problem solving and experimental exercises and demonstrations. The basic objective of this subject "Oscillations and Waves" is to deepen these issues with a greater degree of generalization, formalizing and deepening problems of great interest from a classic Newtonian approach. Although it is intended a general understanding of vibrational and wave phenomena, special attention will be devoted to mechanical vibrations and waves, as they constitute the



starting point for understanding and modeling other wave behavior in different areas of physics. Although the subject "Oscillations and Waves" is independent of the subject "Laboratory Experimental Mechanics and Waves", the relationship between the two is very narrow. In particular, students take many practices of vibrations and waves of mechanical nature, such as one-dimensional waves (acoustic tubes, strings, springs) or two-dimensional (Chladni plates), and in all cases dealt with the experimental results from adequacy of knowledge and theoretical models.

In short, this subject has a fundamental and highly relevant for the degree. It deals with a certain degree of mathematical formalization but primarily aimed at providing basic tools to address fundamental problems of waves, affecting the physical content rather than its formulation as a body of theory, more like the course "Mechanics II."

## PREVIOUS KNOWLEDGE

### Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

### Other requirements

The subject "Oscillations and Waves", like other materials second and third year of the Degree in Physics, discusses further aspects and the language studied most basic and conceptual way the contents of the first subject Physics II course. For this reason it is essential to have successfully completed this course. You also need to master the mathematical basis acquired on the subject "Mathematics" in the first course and previous courses (high school).

## COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

### 1105 - Degree in Physics

- Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.
- To know how to apply the knowledge acquired to professional activity, to know how to solve problems and develop and defend arguments, relying on this knowledge.
- Developing learning skills so as to undertake further studies with a high degree of autonomy.
- Problem solving: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems .
- Be able to understand and master the use of the most commonly used mathematical and numerical methods.
- Modelización y resolución de problemas: Saber resolver problemas, siendo capaz de identificar los elementos esenciales de una situación y de realizar las aproximaciones requeridas con objeto de reducir los problemas a un nivel manejable.



- Destrezas Generales y Específicas de Lenguas extranjeras: Mejorar el dominio del inglés científico-técnico mediante la lectura y acceso a la bibliografía fundamental de la materia.
- Ser capaz de proseguir con el estudio de otras materias de la física gracias al bagaje adquirido en el contexto de esta materia.
- Communication Skills (written and oral): Being able to communicate information, ideas, problems and solutions through argumentation and reasoning which are characteristic of the scientific activity, using basic concepts and tools of physics.
- Comprensión teórica de los fenómenos físicos: Conocer y comprender los fundamentos de la Mecánica clásica y de las ondas, así como del bagaje matemático para su formulación y de los fenómenos físicos involucrados y de las aplicaciones más relevantes.
- Cultura General en Física: Haberse familiarizado con las áreas más importantes de la mecánica en relación con la Física en general, y con enfoques que abarcan y relacionan diferentes áreas de la Física.

## **LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)**

- Understand the basic phenomenology of the oscillatory motion, including the damped oscillations, forced oscillations and resonance in specific mechanical problems and general models which are valid in many areas of physics.
- Understand and be able to solve problems in which there is coupling among the equations of motion (coupled systems). In particular, in problems of coupled oscillators as a modellic workframe for vibration pattern in molecules and solids, which leads to the continuous wave description.
- To assimilate the basics of wave motion and in particular the relationship with the properties of the medium. Knowing the type of media that allow the propagation of a deformation as a transverse and/or longitudinal wave. To know (and recognize) typically wave phenomena as interference, diffraction, polarization, pulses, and bandwidth theorem.

## **DESCRIPTION OF CONTENTS**

### **1. Simple and damped harmonic oscillator**

Periodic phenomena. Simple harmonic oscillator. Complex notation. Examples of physical phenomena obeying this model. Harmonic oscillations in two dimensions. Lissajous trajectories. Damped oscillations. Relaxation time. Energy of simple and damped harmonic oscillators.

**2. Forced oscillations**

Forced oscillator. Transient effects. Harmonic force. Resonance curve and quality factor. Physical examples of interest. Absorption amplitude and elastic amplitude. Energy of a forced harmonic oscillator. Superposition principle. Periodic force and Fourier analysis. Non-linear oscillations. Forced non-linear oscillator: combinatory frequencies.

**3. Coupled oscillations**

Coupling of two oscillators. Symmetric and antisymmetric modes. General theory of small amplitude oscillations. Normal modes. Triatomic linear molecule. N coupled oscillators: vibrations of a crystal lattice. N forced oscillators. Continuum limit.

**4. Normal modes of continuous systems**

Free vibrations of stretched strings. Wave equation. Solution with boundary conditions: normal modes. Continuous systems. Equations of motion of an elastic solid. Longitudinal and transverse waves in an elastic solid. Stationary waves in two and three dimensions. Physical examples.

**5. Progressive waves**

Stationary and progressive waves. One-dimensional wave equation. Examples. General solution of the wave equation. Phase velocity. Attenuation. Energy of a wave. Superposition of waves and wave packets. Spectral representation of a wave packet and bandwidth theorem. Dispersion relation and group velocity. Waves in two and three dimensions. Waves at interfaces: reflection and transmission coefficients. Introduction to oscillatory phenomena: interference, diffraction, polarization, Doppler effect.

**WORKLOAD**

ACTIVITY	Hours	% To be attended
Theory classes	38,00	100
Tutorials	7,00	100
Development of individual work	28,00	0
Study and independent work	39,50	0
<b>TOTAL</b>	<b>112,50</b>	

**TEACHING METHODOLOGY**

Contact teaching 40%

Theoretical and practical classes: It addresses the conceptual and formal matter and resolution of problems or cases as the application of theoretical concepts. They are based mainly on lectures with dialogue and the use of teaching tools such as experimental demonstrations, animations or videos, graphic



solutions, projected presentations, etc.).

Group tutoring sessions or work in small groups: focus on student work and their active participation: resolving doubts in dealing with theoretical concepts and problem solving, reinforcement in areas of greatest difficulty, questionnaires conceptual, experimental demonstrations relevant to the case studies and associated with a component of continuous assessment, verification of student progress in the field.

Student's personal work 60%

- Study of the theoretical.
- Troubleshooting individually or in groups
- Individual tutorials: querying of the teacher on student concerns and difficulties encountered in the study and resolution of problems, or discussion on topics of interest, bibliography, etc.

## EVALUATION

The assesment system is as follows:

1) Written examinations: One part will assess the understanding of the theoretical-conceptual and formal nature of the subject, both through theoretical questions, conceptual questions and numerical or simple particular cases. Another part will assess the applicability of the formalism, by solving problems and critical capacity regarding the results. Proper argumentations and adequate justifications will be important in both cases. Mark A (between 0 and 10)

2) Continuous assessment: assessment of exercices and problems presented by students, questions proposed and discussed in class, oral presentation of problems solved or any other method that involves an interaction with students. Mark B (between 0 and 1)

Final mark: Group A:  $\max(A, 0,7 \cdot A + 3 \cdot B)$ ; Group B:  $\min(10, A+B)$

Subject to compliance with the compensation criteria established for this purpose, note this course can be averaged with other others belonging to the same matter, so as to pass the course.

## REFERENCES

### Basic

- "Vibraciones y Ondas" A. P. French, ed. Reverté, 1996.
- "Dinámica clásica de las partículas y sistemas". J.B. Marion. Ed Reverté, 2000.
- Classical Mechanics John R. Taylor, 2005 University Science Books





### Additional

- The Physics of vibrations and waves H.J. Pain. John Wiley & Sons, 2005
- Vibrations and waves del prof. Walter Lewin del MIT  
( <http://ocw.mit.edu/OcwWeb/Physics/8-03Fall-2004/CourseHome/index.htm> )
- "Fonaments de Física. Vol. 1,2". V. Martinez (Enciclopedia Catalana).
- "Física II: Campos y Ondas", Alonso Finn. Adison Wesley, 1986.
- Física de Feynman, vol. I, ed Pearson.
- "Waves. Berkeley Physics Course" Kittel-Knight-Ruderman. Ed Reverté, 1999.
- The Physics of Vibration A. B. Pippard. Cambridge University Press, 1989.
- "Mathematical methods for physics and engineering" K. F. Riley et al., Cambridge Univ. Press,

### ADDENDUM COVID-19

**This addendum will only be activated if the health situation requires so and with the prior agreement of the Governing Council**

### English version is not available

#### METODOLOGÍA DOCENTE

Durante el mes de febrero 2021, la docencia de teorías y seminarios-trabajos tutelados, pasan a modalidad de videoconferencia síncrona impartida en el horario fijado por la asignatura y el grupo.

A partir del 1 de marzo, se seguirá la modalidad docente indicada en la Guía Docente y en las modalidades docentes aprobadas en las Comisiones Académicas de Título de los meses de julio 2020 y noviembre de 2020, respectivamente, a menos que las autoridades sanitarias y Rectorado indiquen una nueva reducción de presencialidad, en este caso se volvería a la modalidad de videoconferencia síncrona.