

Degree	Type	Year
Physics	OT	4

Contact

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Teaching groups languages

You can view this information at the [end](#) of this document.

Prerequisites

It is highly recommended to have been taken courses in basic physics and mathematics such as statistical physics, thermodynamics, radiation physics and integral/differential calculus.

It would help, though is not a must, some knowledge on fluid dynamics.

Objectives and Contextualisation

To provide those basic and necessary elements for a proper understanding of the basic processes that intervene, from the perspective of physics, in some of the main environmental problems. The subject essentially is a presentation of our current knowledge of geophysical fluids. Also some short presentations will be provided about other areas of physics relevant in environmental issues such as turbulence, energy efficiency, etc.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.

- Plan and perform, using appropriate methods, study, research or experimental measure and interpret and present the results.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Using appropriate methods, plan and carry out a study or theoretical research and interpret and present the results
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project
- Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Learning Outcomes

1. Analyse the evolution in actual emissions of CO₂ (and other greenhouse gases) in relation to measures or containment policies adopted over recent decades and, in case of mismatch, propose viable alternative measures.
2. Apply convolution techniques for obtaining the spectrum of neutron fields detected through spectrometer measurements.
3. Apply the physics of fluids in rotating systems to the study of geophysical fluid dynamics.
4. Assessing the environmental impacts of different energy sources used, their financial cost and the risks associated with their use. Critically evaluate their use depending on the circumstances and factors applicable in every situation.
5. Based on the more general set of equations governing the physics of fluids, obtain their realization in the field of geophysical fluids.
6. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
7. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
8. Compare the relative importance of each of the terms involved in the Navier-Stokes equations and assess their importance according to the process or system to be studied.
9. Critically analyse the different spatial and temporal scales involved in a problem and make the corresponding simplifications for the differential equations governing the process.
10. Critically evaluate the implications that recent advances in paleoclimatology have on our understanding of medium-term evolution in the climate system.
11. Evaluate the different variables involved in the situation analysed, in addition to their relative magnitude, and obtain a rough estimate of the results that may subsequently be obtained following a detailed and rigorous analysis.
12. Explain the explicit or implicit code of practice of one's own area of knowledge.
13. Identify situations in which a change or improvement is needed.
14. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
15. Produce energy-balance models for the climate system in order to make predictions on temperature evolution, and compare the results with measurements obtained in recent decades.
16. Relate the molecular structure of certain atmospheric compounds with climate-system response to anthropogenic or natural actions.
17. Solve differential equations associated to decay chains.
18. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
19. Use the basic principles of thermodynamics in the energy-efficiency analysis of certain energy-generation processes in addition to in the study of the Earth's global energy balance.
20. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
21. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Content

1. Introduction to Atmospheric Physics

- 1.1 Composition and structure of the atmosphere
 - 1.2 Formation and evolution of the Earth's atmosphere
 - 1.3 Spatial and temporal scales in meteorology and climatology
 - 1.4 Measurement of atmospheric variables: sensors and meteorological stations
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2. Thermodynamics of the Atmosphere

- 2.1 Ideal gas law applied to the atmosphere
 - 2.2 Temperature, pressure, and density: vertical gradients
 - 2.3 Humidity: absolute, relative, mixing ratio, dew point
 - 2.4 Virtual temperature and moist air density
 - 2.5 Dry and moist adiabatic ascent. Condensation level and instability
 - 2.6 Parcel equilibrium: stable, unstable, and neutral conditions
 - 2.7 Applications in weather prediction and cloud formation
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3. Aerosol Physics

- 3.1 Definition and classification of aerosols
 - 3.2 Saturation vapor pressure and Clausius-Clapeyron equation
 - 3.3 Surface tension and droplet nucleation
 - 3.4 Köhler curve and activation of condensation nuclei
 - 3.5 Aerosol dynamics: Brownian diffusion, sedimentation, deposition
 - 3.6 Processes of aggregation and coalescence of particles
 - 3.7 Climatic and health impacts of aerosols
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4. Atmospheric Radiation

- 4.1 Monochromatic and spectral intensity
 - 4.2 Planck's law, Wien's law, and Stefan-Boltzmann law
 - 4.3 Beer-Lambert law and atmospheric absorption
 - 4.4 Absorption, emission, and scattering (Rayleigh, Mie)
 - 4.5 Radiative equilibrium of Earth and the greenhouse effect
 - 4.6 Radiative transfer: equation and approximations
 - 4.7 Applications in remote sensing and planetary energy balance
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5. Atmospheric Dynamics

- 5.1 Fundamental forces: pressure, Coriolis, and friction
 - 5.2 Geostrophic and gradient winds
 - 5.3 Thermal wind and jet streams
 - 5.4 Atmospheric turbulence and boundary layer
 - 5.5 Ekman layer and Ekman transport
 - 5.6 Cyclones and anticyclones. Frontal systems
 - 5.7 Atmospheric waves: gravity waves and Rossby waves
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6. Planetary Phenomena and Climate Variability

- 6.1 General circulation of the atmosphere (Hadley, Ferrel, Polar cells)
- 6.2 Rossby waves: formation, propagation, and effects
- 6.3 Climate oscillations: El Niño - Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), Madden-Julian Oscillation (MJO)
- 6.4 Variability and climate change: natural and anthropogenic forcings
- 6.5 Impacts of these phenomena on regional and global meteorology

7. Applications in Environmental Physics

- 7.1 Meteorological and climate modeling
- 7.2 Air quality: dispersion of pollutants
- 7.3 Solar radiation and energy resources
- 7.4 Effects of aerosols and clouds on climate
- 7.5 Meteorological hazards and prediction of extreme events

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Exercises resolution sessions	16	0.64	
Theoretical sessions	33	1.32	
Type: Autonomous			
Student personal work	93	3.72	

Theoretical lectures to introduce some basic concepts.

Practical sessions to solve those exercises that have been previously handed to the student.

Students will give an oral exposition based on scientific publications.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
First partial examination	30 %	2.5	0.1	9, 1, 2, 10, 4, 15, 13, 16, 17
Oral expositions	30 %	0.5	0.02	7, 12, 6, 14, 18, 20, 21
Recovery examination	70 %	2.5	0.1	

Continuous Assessment

- First partial exam on the contents studied up to that point: 30% of the final grade.
- Oral presentation in class on proposed topics related to the subject matter: 30% of the final grade.
- Second partial exam, covering all contents of the course related to the topics of the second half of the term: 40% of the final grade.

To be able to calculate the average and include all activities, the student must obtain a minimum grade of 3.0 in each of the assessed parts.

Furthermore, to pass the course, the weighted average of the three activities must be at least 5.0.

The make-up exam will consist of two parts, corresponding to each of the partial exams. The student will only need to take the part in which they scored less than 3.0. The oral presentation is not recoverable.

Students who have not participated in any of the partial exams, make-up exams, or oral presentations will receive a final grade of "Not Evaluated".

There will be no grade improvement exam for those who have already passed the course.

Single Assessment

Students who choose the single assessment modality must take a final exam consisting of:

- First partial exam on the contents studied up to that point: 30% of the final grade.
- Second partial exam, covering all course contents related to the topics of the second half of the term: 40% of the final grade.
- Submission of the report of the chosen and completed coursework (30% of the final grade). There will be no oral presentation.

These tests will take place on the same day, time, and place as the second partial exams in the continuous assessment modality.

To calculate the average, the student must obtain at least a 3.0 in each part, and to pass the course, the weighted average of the three activities must be at least 5.0 out of 10.

If the final grade is below 5, the student will have another chance to pass the course by taking a make-up exam, which will be held on a date set by the program coordination. This exam will allow recovery of 70% of the grade corresponding to the partial exams. The coursework part is not recoverable.

Bibliography

Course reference books

J.M.Wallace i P.V. Hobbs, Atmospheric Science, Academic Press, New York, 1977

B. Cushman-Roisin, Introduction to Geophysical Fluid Dynamics, Prentice Hall, 1994

Other basic references

S.Pond, G.L.Pickard, Introductory Dynamical Oceanography, Butterworth, 1997

John Houghton, The Physics of Atmospheres, 3rd ed. Cambridge University Press, 2002

C.D. Ahrens, Meteorology today (7th ed.), Brooks/ColePacific Grove, 2003

Raymond T. Pierrehumbert, Principles of planetary climate, Cambridge University Press, 2010

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Advanced References

S. P. Arya, Introduction to micrometeorology, Academic Press, 1988

S. P. Arya, Air pollution. Meteorology and dispersion, Oxford University Press, New York, 1999

E. Boeker, R. van Grondelle, Environmental Physics, Wiley, London 1999

E. Boeker, R. van Grondelle, Environmental Science, Wiley, Chichester 2001

G.S. Campbell, J. M. Norman, An introduction to Environmental Biophysics, Springer, 1998.

W. Cotton, R. A. Pielke, Human Impacts on Weather and Climate, Cambridge, 1995.

S. Eskinazi, Fluid Mechanics and Thermodynamics of our Environment, Academic Press, 1975.

K. N. Liou, An introduction to atmospheric radiation, Academic Press, 2002

Software

No specific software will be used.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this [link](#). To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan	second semester	afternoon
(TE) Theory	1	Catalan	second semester	afternoon