COURSE DATA

Data Subject	
Code	34249
Name	Statistical and numerical methods
Cycle	Grade
ECTS Credits	8.0
Academic year	2015 - 2016

Study (s)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Faculty of Physics	2	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	9 - Statistical and numerical methods	Obligatory

Coordination

Name	Department
CASES RUIZ, MANUEL RAMON	180 - Atomic, Molecular and Nuclear Physics
MORENO MENDEZ, JOSE FELICISIMO	345 - Earth Physics and Thermodynamics

SUMMARY

The extraction of information from experimental data requires the use of knowledge of probability and statistical methods that are essential to make measurements of physical quantities. On the other hand, a large number of problems associated with physical systems have no analytical solution so that its resolution must be addressed from the numerical analysis.

The main objective will be to provide students with the essential statistical methods for experimental data and numerical models to be able to address those problems without physical and analytical solution or calculation involving very high volumes.

In addition, the material contains a strong practical component in which it is intended that students acquire fluency in programming a high-level language programming algorithms and models run on a computer and be familiar with numerical concepts such as accuracy, errors rounding, order of convergence as well as problems in the programming of numerical algorithms.

The descriptors proposed in the document Curriculum Degree in Physics established to address the following topics: Probability, probability distributions, error propagation, Central Limit Theorem,

maximum likelihood, adjustments of experimental data, statistical tests, quality adjustments, introduction to Monte Carlo techniques. Roots of functions, linear systems, eigenvalue problems, interpolation, numerical differentiation and integration, differential equations.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

Knowledge of Linear Algebra and differential and Integral Calculus acquired in high school and in the subjects of Mathematics, Mathematical Methods I and II. Experience in performing measurements and analysis of experimental data acquired in the subject Introduction to Experimental Physics. Computers and programming experience gained in the subject Informatics.

OUTCOMES

1105 - Degree in Physics

- 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.
- Ability to collect and interpret relevant data in order to make judgements.
- Capacity to communicate information, ideas, problems and solutions to a specialist and a general audience.
- 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.
- Prob. solving and computer skills: be able to perform calculations independently, even when a small PC or a large computer is needed, including the development of software programmes.
- 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.
- 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.

LEARNING OUTCOMES

-Application of numerical analysis to scientific problems.
-Know the necessary statistical tools for data analysis.
-Learning to program numerical algorithms in a high level language.
-Learn to use numerical and scientific software libraries.
-Develop the ability to program simple physical models and install the appropriate software on a computer.
-Learn to treat experimental data numerically.

DESCRIPTION OF CONTENTS

1. Numerical Methods. Solving nonlinear equations.

Introduction. Bisection Method. Newton Raphson Method.

2. Numerical Methods. Linear problems.

Linear algebra problems. LU decomposition of a matrix. Solving systems of ecuaciones. Inverse matrix. Values and eigenvectors. Jacobi method.

3. Numerical Methods. Optimization.

Minimization of a function. Simplex method. Gradient method.

4. Numerical Methods. Interpolation.

Lagrange interpolation. Divided differences. Interpolation with Splines.

5. Numerical Methods. Numerical Integration and Derivation.

Numerical derivation. Richardson extrapolation. Rules integration: Trapezoidal. Simpson, Boole. Compound rules. Romberg integration.

6. Numerical Methods. Numerical Resolution of Differential Equations.

Ordinary differential equations. Integration algorithms. Euler method. Midpoint method. Predictor corrector method. Runge-Kutta methods. Quality rules integration. Finite differences and finite elements.

7. Statistical Methods. Probability and Statistics. General concepts

Definition of probability. Random variables. Calculation of probabilities. Bayes Theorem.

8. Statistical Methods. Probability Distributions.

Probability density functions. General properties of probability distributions. Expected values. Average and variance value. Distributions of more than one variable. Binomial Distribution. Poisson distribution. Gaussian distribution. Other distributions.

9. Statistical Methods. Errors. Convergence and the Law of Large Numbers.

Linear functions of random variables. Change of variables. Error propagation. Sampling. Sample inference. Law of large numbers. Central Limit Theorem.

10. Statistical Methods. Fitting of experimental data.

Estimators. Properties of estimators. Linear functions in the parameters. Parameter estimation: maximum likelihood, least squares. Nonlinear functions in the parameters. Errors in the parameters. Time series.

11. Statistical Methods. Confidence intervals. Test of hypotheses.

Confidence intervals. Estimation of confidence intervals. Gaussian confidence levels. Limits. Test of hypothesis: Neyman Pearson. Student t and F. Goodness settings: likelihood ratio, Chi-square, Kolmogorov-Smirnov.

12. Statistical Methods. Introduction to Monte Carlo techniques.

Monte Carlo methods. Random numbers. Uniform random number generators. Sampling distributions. Inverse transformation method. Acceptance-rejection method. Monte Carlo integration.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	45,00	100
Computer classroom practice	35,00	100
Development of individual work	30,00	0
Study and independent work	85,00	0
TOTAL	**195,00**	

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 and the use of dialogic teaching tools as a graphical representation of solutions, design presentations, spreadsheet programs, etc.)..

Laboratory sessions in the computer room: Realization and implementation of programs in computer room sessions where simple algorithms are coded. Resolving doubts in dealing with theoretical concepts to problem solving and program implementation. Reinforcing aspects that are more difficult, and verification of student progress in the field, associated with a component of continuous assessment.

Student's personal work 60%

- Study of the theoretical.

- Problem solving, multiple choice questions, and works (individually or in groups)

- Performing exercises using computer interpretation, conclusions and implementation of memory for communication.

- 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.

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.

COMMENTS: The weight of each item is established in accordance to the agreements of the Bachelor's Degree in Physics Commission (CAT).

REFERENCES

Basic

- J.H. Mathews y KD Fink. Métodos Numéricos con Matlab.Prentice Hall. Madrid 2000.
- J.D. Faires y R. Burden. Métodos Numéricos. Thompson-Paraninfo (2004).
- R.J. Barlow. A Guide to the Use of Statistical Methods in the Physical Sciences. Wiley & Sons 1989.
- Glen Cowan. Statistical Data Analysis. Oxford University Press 1998.
- C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientist, Third edition, Mc Graw-Hill International Edition.

Additional

- G. M. Phillips y P.J Taylor, Theory and applications of Numerical Analysis, Academic Press, 1994
- Press, Teukolsky, Numerical Recipes, Cambridge University Press.
- S. Brandt, Data Analysis: Statistical and Computational Methods for Scientists and Engineers, Springer 1999.
- W.T. Eadie Statistical Methods in Experimental Physics. Ed. North Holland P.C.
- F. James. Statistical Methods in Experimental Physics. World Scientific 2006.
- M.G. Kendall and S. Stuart: The Advanced Theory of Statistics. Charles Griffin & Co. 3 volumenes.