INSTITUTO DE FÍSICA
FACULTAD DE FÍSICA

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| COURSE | : | **PHYISICS OF ELECTRIC DISCHARGES** |
| TRANSLATION | : | FÍSICA DE LAS DESCARGAS ELÉCTRICAS |
| NUMBER | : | FIM4015 |
| CREDITS | : | 15 UC / 9 SCT |
| REQUISITES | : | FIZ2700 |
| CONECTOR | : | AND |
| RESTRICTIONS | : | 030501 |
| CHARACTER | : | OPTATIVE |
| FORMAT | : | THEORETICAL LECTURES, LABORATORY QUALIFICATION |
| | : | STANDARD |
| FORMATIVE LEVEL | : | DOCTORATE |
| DISCIPLINE | : | PHYSICS |

## I. COURSE DESCRIPTION

The course delivers physical concepts such as formalism that describe qualitatively and quantitatively the processes of electrical breakdown in gases and the formation of plasmas. At the end of the course, students will be able to carry out a computer simulation of specific situations such as the interpretation of experimental results applicable to a doctoral research.

## II. LEARNING OUTCOMES

1. Know and understand the empirical phenomenology and the theoretical description of electric discharges in gases.
2. Mastering the application and analysis of computational simulation tools and diagnostic techniques.

## III. CONTENT

THEORY:

1. Diffusion of charged particles in constant electric fields. Electron drift, electron diffusion, ions, ambipolar diffusion.
2. Production and decay of charged particles. Ionization by impact with electrons, recombination, secondary emission.
3. Electrical breakdown of gases. Paschen curve, space charge growth, Townsend coefficients, primary and secondary processes, failure criterion.
4. Electrical diagnostics. V-I curve of a probe, Langmuir probe, double probe, parameter measurement, plasma.
5. Kinetic theory. Boltzmann equation, electron energy distribution function.
6. Download glow. Visual characteristics, V-1 curve, sheaths, positive column.
7. Arc discharge. Types, initiation, processes at the cathode, V-I curve.
8. Spark and corona downloads. Avalanches, streamers,

discharge channel, crown, leaders, beam.
9. Laser spark: general description, interaction of laser with gases, interaction of laser with solids, LTE and non-LTE approximations, expansion dynamics of laser plasmas in gases.
10. Pulsed Capillary Discharge: overview, effect
hollow cathode, ionization waves, applications.

11. Surface Barrier Discharge (DBD): General description, I-V characteristic curve, electrode configurations, filamentary discharge, applications.
12. Radio-Frequency (RF) Discharges: overview, electron drift oscillations in a gas, radio-frequency sheaths, capacitively coupled plasma (CCP), inductively coupled plasma (ICP), applications.

LABORATORY:
1. Measurement of breaking power. Paschen curve.
2. Transient discharge breakdown delay in gases. Statistical study of electrical discharge breakdown delay times.
3. Transient discharge of hollow cathode. Egg cathode effect in transient electric discharges.
4. Continuous discharge of hollow cathode. Continuous discharge V-I curve.
5. Electrical probes. Measurement of parameters in download.

Numerical simulations:

1. Computer simulation of radio frequency discharge.
2. Numerical solution of the Boltzmann equation.
3. Calculation of ionization coefficients in stationary plasmas.
4. Calculation of energy distribution functions of electrons in plasmas out of thermal equilibrium.

## IV. METHODOLOGICAL STRATEGIES

Theoretical classes.
Problem solving.
Computational simulation of experimental situations.
Development of experiments in electric discharges.

## V. EVALUATIVE STRATEGIES

Homework 30%
Computational simulations 30%
Reports of experimental practices 40%

## VI. BIBLIOGRAPHY

**REQUIRED**

Y. P. Raizer, Gas Discharge Physics (Springer, 1997)
B. M. Smirnov, Physics of Ionized Gases (Wiley Inter- Science, 2001)
B. Chapman, Glow Discharge Processes ( Wiley Inter- Science, 1980)
E. M Bazelyan y Y. P. Raizer, Spark Discharge (CRC Press, 1988)
P. Chabert y N. Braithwaite, Physics of Radio-Frequency Plasmas (Cambridge University Press, 2011)
M. A. Liebermann y A. J. Lichtenberg, Principles of Plasma Discharges and material Processing (Wiley Inter-Science, 1994)
F. F. Chen y J. P. Chang, Lecture Notes on Principles of Plasma Processing (Kluwer Academics, 2003)

**OPTIONAL**

N/A

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