NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF SCIENCES

ENGINEERING PHYSICS PROGRAM

IF242 – INTRODUCTION TO METROLOGY

I. GENERAL INFORMATION

CODE	**:**	IF242 Introduction to Metrology
SEMESTER	**:**	4
CREDITS	**:**	3
HOURS PER WEEK	**:**	5 (Theory–Practice–Laboratory)
PREREQUISITES	**:**	CM211 Advanced Differential and Integral Calculus
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Engineering Physics

II. COURSE DESCRIPTION

The course prepares students in the understanding and application of the basic principles of metrology for measuring the actual value of variables of a physical system. Students understand the concepts of error, precision, accuracy and uncertainty related to the measurement of any physical variable, as well as calculate the statistical parameters of measurement errors.

III. COURSE OUTCOMES

At the end of the course, students:

1. Select equipment and instruments to use, properly, according to the experience to develop.
2. Identify the main variables of the experiment and determinate their units, ranges of variation and tolerance.
3. Measure the variables with high accuracy and exactitude and verify the consistency of values.
4. Tabulate result orderly and realize graphics that show relations and dependency between variables.
5. Calculate statistically important parameters based on data and formulate regression models for different variables.
6. Use computing tools to visualize and process data.
7. Interpret their results, generalize and formulate conclusions.
8. Compare the experimental and theoretical results, verifying and validating laws, principles and theorems.

IV. LEARNING UNITS

1. METROLOGY

Metrology / International units of measurement / International Bureau of Weights and Measures / Chains of traceability / Actual measurements and standards / Practical aspect of measurement / Industrial metrology / Legal metrology.

2. ERRORS AND UNCERTAINTIES

Errors and uncertainties / Importance of uncertainties / Experimental measures / Examples / Best estimate / Significant figures / Discrepancy / Comparison between pattern value and experimental measure / Pilot relationship using graphs.

3. UNCERTAINTIES

Uncertainty / Fractional uncertainty / Multiplication of two measured values / Sum / Difference / Product and ratio / Independent uncertainties.

4. UNCERTAINTIES OF ONE-VARIABLE FUNCTION

Uncertainty of arbitrary one-variable function / Propagation of uncertainty for functions of more than one variables.

5. STATISTICAL ANALYSIS

Statistical analysis of random uncertainties / Random and systematic errors / Average and standard deviation / Standard deviation as a measure of uncertainty / Standard deviation of the average.

6. NORMAL DISTRIBUTION

Normal distribution / Distributions and histograms / Limit of a distribution. / Confidence limit.

7. CHAUVENET CRITERIA

Elimination of doubtful data / Normal distribution / Distributions and histograms. / Limit of a distribution / Confidence limit.

8. LEAST SQUARES ADJUSTMENT, USE OF SOFTWARE

Least squares adjustment: for a line, calculation of “a” and “b” / Calculation of uncertainties / Covariance.

9. USE OF SOFTWARE

Use of software for curves adjustment. / Origin / MATLAB.

10. POISSON DISTRIBUTION

Poisson distribution and nuclear measurements / Demonstrative experiment / Poisson distribution.

11. REGULATIONS

Seminar of ASTM standards / Seminar of NTP standards / Seminar of ISO/IEC 17025 standards.

V. LABORATORY AND PRACTICAL EXPERIENCE

Students carry out four laboratory experiences to measure different physical variables and using diverse types of instruments.

VI. METHODOLOGY

The course takes place in theory, practice and laboratory sessions. In theory sessions, faculty presents concepts, theorems, methods and applications. In the practice sessions, students solve different problems related to metrology, instrument calibration, measurement errors and uncertainties. In laboratory sessions, students carry out diverse experiments to analyze the measurement of different physical variables using different instruments, as well as use MATLAB software for numerical calculation. Student active participation is promoted.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + 2*EF + PP) / 4

EP: Mid-term Exam EF: Final Exam
PP: Average of practice grades.

VIII. BIBLIOGRAPHY

1. JOHN R, TAYLOR.
   An Introduction to Errors Analysis, University of Science Books, 2nd Edition, 2010.
2. ASTM, NTP and ISO/IEC 17025 Standards.