الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي والبحث العلمي

نموذج

عرض تكوين ماستر ذو مسار مدمج مع الليسانس أكاديمي

2027 – 2026

التخصص	الشعبة	ميدان
الحوسبة الكمومية والتكنولوجيات الكمومية	الفيزياء	علوم المادة

PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

Template

Training Program Proposal

L.M.D.

Master Program with an Integrated Licence Curriculum

Academic

2026 – 2027

Domain	Branch	Speciality
Matter Sciences	PHYSICS	Quantum Computing and Quantum Technologies

I– Semester-Based Teaching Organization Sheet

Comité Pédagogique National du Domaine
CPND-SM
Sciences de la Matière

MCIL : Quantum Computing and Quantum Technologies

L1 Semester 1 :

Teaching Unit	Subjects	THW	Weekly Hours			Other	Coeff.	Credits	Evaluation Mode	
	Title	15 weeks	Lectures	TS*	LS*				Continuous assessment	Final exam
Fundamental Unit FU 1 Credits : 18 Coefficient : 09	Algebra 1	67h30	3h00	1h30		82h30	3	6	33%	67%
	Analysis 1	67h30	3h00	1h30		82h30	3	6	33%	67%
	Mechanics	67h30	3h00	1h30		82h30	3	6	33%	67%
Methodology Unit MU 1 Credits : 9 Coefficient : 5	Physics Lab 1	22h30			1h30	27h30	1	2	50%	50%
	Computer Organization 1	37h30	1h00		1h30	37h30	2	3	50%	50%
	Algorithmics 1	45h00	1h30		1h30	55h00	2	4	50%	50%
Discovery Unit DU 1 Credits : 1 Coefficient : 1	Probabilities and Statistics	45h00	1h30	1h30		2h30	1	1	33%	67%
Transversal Unit TU 1 Credits : 2 Coefficient : 2	Critical Thinking and Problem Solving	22h30	1h30			2h30	1	1		100%
	History of Algeria	22h30	1h30			2h30	1	1		100%
Total Semester 1		397h00	16h00	6h00	4h30	375h00	17	30		

- Tutorial sessions
- Lab sessions

MCIL : Quantum Computing and Quantum Technologies

L1, Semester 2 :

Teaching Unit	Subjects Title	THW 15 weeks	Weekly Hours Lectures	TS*	LS*	Other	Coeff.	Credits	Evaluation Mode Continuous assessment	Final exam
Fundamental Unit FU 1 Credits : 18 Coefficient : 09	Algebra 2	67h30	3h00	1h30		82h30	3	6	33%	67%
	Analysis 2	67h30	3h00	1h30		82h30	3	6	33%	67%
	Electricity and Magnetism	67h30	3h00	1h30		82h30	3	6	33%	67%
Methodology Unit MU 1 Credits : 9 Coefficient : 5	Physics Lab 2	22h30			1h30	27h30	1	2	50%	50%
	Computer Organization 2	37h30	1h00		1h30	37h30	2	3	50%	50%
	Algorithmics 2	45h00	1h30		1h30	55h00	2	4	50%	50%
Discovery Unit DU 1 Credits : 1 Coefficient : 1	General chemistry	22h30	1h30			2h30	1	1		100%
Transversal Unit TU 2 Credits : 2 Coefficient : 2	Introduction to Scientific Writing with LaTeX and Linux environment	22h30			1h30	2h30	1	1		100%
	Patriotism and Citizenship	22h30	1h30			2h30	1	1		100%
Total Semester 2		375h00	14h30	4h30	6h00	375h00	17	30		

- Tutorial sessions
- Lab sessions

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Sciences de la Matière

II- Detailed Curriculum by Subject

Adapt the schedule for lectures and tutorials (TEs) based on the weekly in-person class hours (WIC) and the weekly self-study hours (WSS).

Detailed syllabus by subject for Semester 1

Semester 1
course title : Algebra 1
Teaching Unit : Fundamental
Credits 6
Coefficient 3

Course Objectives
This course introduces the mathematical foundations required for Quantum Computing and Quantum Technologies through logic, algebraic structures, complex numbers, discrete mathematics, and introductory linear algebra. It aims to develop abstraction, mathematical rigor, and computational reasoning.
Recommended Prerequisite Knowledge
Secondary-level scientific mathematics.
Course Content

Chapter 1: Mathematical Logic and Reasoning (2 Weeks)
- Propositional logic.
- Truth tables.
- Quantifiers and predicates.
- Mathematical reasoning :
  - direct proof,
  - contradiction,
  - contraposition,
  - mathematical induction.
  - Logical equivalence.
- Introduction to Boolean algebra.
- Logic gates and binary representation.

Chapter 2: Sets, Relations, and Applications (3 Weeks)
- Sets and subsets.
- Cartesian products.
- Mappings :
  - injection,
  - surjection,
  - bijection.
- Direct and inverse image.
- Equivalence relations and equivalence classes.
- Order relations.
  - Basic combinatorics :
  - permutations,
  - combinations,
  - binomial coefficients.

Chapter 3: Complex Numbers (3 Weeks)
- Algebraic operations on complex numbers.
- Geometric representation.
- Modulus and argument.
- Trigonometric and exponential forms.
- Euler and De Moivre formulas.
- Roots of unity.

Chapter 4: Introduction to Algebraic Structures (3 Weeks)

- Internal composition laws.
- Groups:
  - definition,
  - subgroups,
  - cyclic groups.
- Introduction to rings and fields.
- Finite fields:
  - example of Z/pZ.

Chapter 5: Fundamentals of Linear Algebra (4 Weeks)

- Vector spaces over R and C.
- Vector subspaces.
- Linear combinations.
- Span and basis.
- Linear independence.
- Dimension.
- Coordinate systems.
- Introduction to matrices.
- Gaussian elimination.
- Systems of linear equations.

Assessment Method

- Final Examination.
- Continuous Assessment.

References

- Sheldon Axler, Linear Algebra Done Right.
- Gilbert Strang, Introduction to Linear Algebra.
- Kenneth Rosen, Discrete Mathematics and Its Applications.

Semester 1
course title : Analysis 1
Teaching Unit : Fundamental
Credits 6
Coefficient 3

Course Objectives

This course introduces the foundations of real analysis and mathematical tools required for physics, quantum computing, and computational sciences. Emphasis is placed on rigorous reasoning, convergence, continuity, differentiability, and mathematical modeling.

Recommended Prerequisite Knowledge

Secondary-level mathematics.

Course Content

Chapter 1: Real Numbers and Topology of R (2 Weeks)

- Real numbers as an ordered field.
- Intervals.
- Upper and lower bounds.
- Archimedean property.
- Open and closed sets.
- Neighborhoods.
- Absolute value and distance.

Chapter 2: Sequences and Convergence (3 Weeks)

- Numerical sequences.
- Limits and convergence.
- Monotone sequences.
- Cauchy sequences.
- Subsequences.
- Limit superior and limit inferior.
- Recursive sequences.
- Introduction to numerical convergence algorithms.

Chapter 3: Functions of One Variable (3 Weeks)

- Limits of functions.
- Continuity.
- Uniform continuity.
- Intermediate value theorem.
- Inverse functions.
- Landau notation and asymptotic behavior.

Chapter 4: Differentiation and Applications (3 Weeks)

- Derivative and differential.
- Geometric interpretation.
- Rolle theorem.
- Mean Value Theorem.
- Local extrema.
- Convexity.
- Curve sketching.
- Optimization applications.

Chapter 5: Elementary Functions and Complex Exponentials (2 Weeks)

- Exponential and logarithmic functions.

- Trigonometric functions.
- Hyperbolic functions.
- Complex exponentials.
- Oscillatory models and wave interpretation.

Chapter 6: Taylor Expansion and Function Approximation (2 Weeks)

- Polynomial approximation of functions.
- Taylor polynomials.
- Taylor theorem with remainder.
- Maclaurin series of elementary functions.
- Local error estimation.

Assessment Method

- Final Examination.
- Continuous Assessment.
- Problem-solving sessions.

References

1. Bougrov & Nikolski, Higher Mathematics.
2. Rudin, W. (1976). Principles of mathematical analysis (3rd ed.). McGraw-Hill Professional.
3. Piskunov, N. (1974). Differential and integral calculus. Moscow: Mir Publishers.
4. Apostol, T. M. (2019a). Calculus, volume 1 (2nd ed.). Wiley.
5. Apostol, T. M. (2019b). Calculus, volume 2 (2nd ed.). Wiley.
6. Abbott, S. (2015). Understanding Analysis. Springer New York.
7. Davidson, K. R., & Donsig, A. P. (2001). Real Analysis with Real Applications. Pearson.
8. Zorich, V. A. (2018). Mathematical analysis I (R. Cooke & O. Paniagua Taboada, Trans.). Springer.
9. Spivak, M. (2008). Calculus (4th ed.). Publish or Perish.
10. Monier, Analyse MPSI.

Semestre : 01
UE : Fondamentale
course title : Mechanics
Credits : 6
Coefficient : 3
Course Objectives:

Comité Pédagogique National du Domaine Sciences de la Matière CPND-SM

To provide students with fundamental concepts of classical mechanics related, through kinematics, dynamics, and work-energy principles.

Prerequisites:

A solid understanding of physics at the secondary school level.

Syllabus:

Mathematical Review (2 weeks)

- Dimensional analysis
- Error analysis and uncertainty estimation
- Vectors

Particle kinematics (5 weeks)

- Rectilinear motion
- Motion in space
- Special types of motion
- Polar, cylindrical, and spherical coordinates
- Relative motion

Particle Dynamics (3weeks)

- Inertia principle and Galilean frames
- Newton's laws of motion
- Force laws
- Angular momentum (point and simple geometric object), torque

Work and Energy (5 weeks)

- Work of a force
- Kinetic and potential energy (gravitational, elastic) (linear and rotational motion)
- Non-conservative forces

Assessment Method :

Continuous assessment: 33% – Final exam: 67%

References (books and handouts, websites, etc.):

1. Kleppner, D., Kolenkow, R. (2014). An Introduction to Mechanics. United Kingdom: Cambridge University Press.
2. Halliday, D., Resnick, R., Walker, J. (2021). Fundamentals of Physics, Extended. United Kingdom: Wiley.
3. Young, H., Young, H. D., Freedman, R. A. (2019). University Physics with Modern Physics. United Kingdom: Pearson.
4. Giancoli, D. C. (2008). Physics for Scientists & Engineers with Modern Physics. United States: Pearson Prentice Hall.
5. Morin, D. J. (2008). Introduction to Classical Mechanics: With Problems and Solutions. Netherlands: Cambridge University Press.

Semester 1 –
Methodology Unit
Course Title: Physics Lab Sessions 1

Course Objectives:

- Reinforce theoretical knowledge acquired in *the Mechanics* course, including error analysis.
- Enable students to observe and visualize phenomena related to classical mechanics through hands-on experiments.

Prerequisites:
A solid understanding of physical sciences at the secondary school level.

Syllabus: *(Select at least 5 lab sessions)*

1- Error calculation
2- Static and dynamic analysis of an oscillating pendulum.
3- Maxwell’s wheel
4- Verification of Newton's laws: Analysis of the motion of a body on an inclined plane (with and without friction).
5- Study of free fall and projectile motion. FREE FALL AND TWO-DIMENSIONAL BALLISTIC MOTION
6- Study of the moment of inertia MOMENT OF INERTIA
7- Study of rectilinear motion
8- Study of the rotation of a rigid body
9- Verification of the fundamentals of circular motion – conservation of mechanical energy

Semester: 01
Teaching Unit: Methodology
course title : Computer Organization 1
Credits: 3
Coefficient: 2
Course Objectives

This course introduces students to the foundations of digital systems and computer organization. It aims to progressively build computational thinking through number systems, Boolean logic, combinational circuits, and introductory computer architecture concepts. The course emphasizes practical understanding through simulation and design activities adapted to first-year students.

Recommended Prerequisite Knowledge

- Basic mathematics.
- Elementary programming notions.
- Basic electricity concepts.

Course Content

Chapter 1: Introduction to Digital Systems (1 Week)

- Evolution of computing systems.
- Analog vs. digital systems.
- Information representation.
- Hardware and software overview.

Chapter 2: Number Systems and Data Representation (3 Weeks)

- Decimal, binary, octal, and hexadecimal systems.
- Conversion between number systems.
- Binary arithmetic:
  - addition,
  - subtraction,
  - multiplication.
- Signed number representation:
  - sign-magnitude,
  - one’s complement,
  - two’s complement.
- Floating-point representation:
  - IEEE 754 basics.
- Error detection:
  - parity,
  - Hamming code (introduction).

Chapter 3: Boolean Algebra and Logic Gates (3 Weeks)

- Boolean algebra fundamentals.
- Boolean theorems and simplification.
- Logic gates:
  - AND,
  - OR,
  - NOT,
  - NAND,
  - NOR,
  - XOR,
  - XNOR.

- Truth tables.
- Canonical forms.
- Karnaugh maps.
- Introduction to Quine–McCluskey method.

Chapter 4: Combinational Logic Circuits (3 Weeks)

- Design methodology of combinational circuits.
- Adders and subtractors:
  - half adder,
  - full adder.
- Multiplexers and demultiplexers.
- Encoders and decoders.
- Comparators.
- Arithmetic Logic Unit (introductory notion).
- Introduction to propagation delay and timing concepts.

Chapter 5: Introduction to Sequential Logic (2 Weeks)

- Sequential vs. combinational circuits.
- Latches and flip-flops:
  - RS,
  - JK,
  - D flip-flops.
- Registers and counters.
- Introduction to finite state machines (FSM).
- Moore and Mealy models.

Chapter 6: Introduction to Digital Design Tools (2 Weeks)

- Introduction to Logisim Evolution.
- Logic circuit simulation.
- Simple digital projects.
- Introduction to hardware debugging.
- Mini-project: design of a simple digital system.

Practical Work / Laboratories

- Binary arithmetic simulation.
- Logic gate implementation.
- Karnaugh map optimization.
- Design of a simple ALU.
- FSM simulation using Logisim Evolution or JFLAP.

Assessment Method

- Final Examination.
- Continuous Assessment.
- Laboratory reports.
- Mini-project evaluation.

References

1. David Harris & Sarah Harris, Digital Design and Computer Architecture.
2. Mano & Ciletti, Digital Design.
3. Bryant & O'Hallaron, Computer Systems: A Programmer's Perspective.
4. John R. Gregg, Ones and Zeros.
5. Logisim Evolution Documentation.

Semester 1
Course title : Algorithmics 1
Teaching Unit : Methodology
Credits 4
Coefficient 2
Course Objectives
This course introduces students to algorithmic thinking, structured programming, and scientific problem-solving using Python. The course aims to progressively develop computational reasoning skills required for Quantum Computing and Quantum Technologies, scientific computing, artificial intelligence, and modern digital systems.

Recommended Prerequisite Knowledge
- Basic mathematics.
- Elementary computer literacy.

Course Content

Chapter 1: Introduction to Computational Thinking (1 Week)
- What is an algorithm?
- Role of algorithms in science and engineering.
- Problem decomposition.
- Flowcharts and pseudocode.
- Introduction to scientific programming environments.

Chapter 2: Python Fundamentals (2 Weeks)
- Variables and data types.
- Input and output.
- Arithmetic and logical operations.
- Python syntax and execution model.
- Basic debugging concepts.

Chapter 3: Conditional Structures (2 Weeks)
- Boolean expressions.
- If statements.
- Nested conditions.
- Multiple-choice structures.
- Introduction to logical reasoning in programs.

Chapter 4: Loops and Iterative Algorithms (3 Weeks)
- While loops.
- For loops.
- Nested loops.
- Counters and accumulators.
- Algorithmic patterns.
- Introduction to algorithm efficiency.

Chapter 5: Data Structures: Lists and Strings (2 Weeks)
- Lists.
- Multidimensional lists.
- Strings and character manipulation.
- Basic searching and sorting concepts.
- Introduction to matrix representation using lists.

Chapter 6: Functions and Modular Programming (2 Weeks)
- Functions and procedures.
- Parameters and return values.
- Local and global variables.

- Recursion (introduction).
- Modular program organization.

Chapter 7: Introduction to Scientific Computing (2 Weeks)

- Numerical computations.
- Introduction to NumPy.
- Basic vector and matrix operations.
- Simple scientific simulations.
- Graph plotting using Matplotlib.

Practical Work / Laboratories

- Python programming exercises.
- Scientific calculator mini-project.
- Matrix manipulation exercises.
- Simple numerical simulations.
- Algorithm debugging activities.

Assessment Method

- Final Examination.
- Continuous Assessment.
- Laboratory reports.
- Mini-project evaluation.

References

1. Allen Downey, Think Python.
2. Charles Severance, Python for Everybody.
3. Eric Matthes, Python Crash Course.
4. Thomas H. Cormen, Introduction to Algorithms.
5. NumPy and Matplotlib official documentation.

Semester: 01
Teaching Unit: Discovery
Course title :: Probability and Statistics
Lecture Hours: 1h30 Lecture + 1h30 Tutorial
Credits: 2
Coefficient: 2
Course Objectives:
This course enables students to learn the essential concepts of probability and statistics, including statistical series with one and two variables, probability on a finite sample space, and random variables.

Part A: Statistics

Chapter 1: Statistical Series with One Variable (2 Weeks)

1. Basic definitions.
2. Concepts of population, sample, variables, and modalities.
3. Different types of statistical variables:
    - Qualitative.
    - Quantitative.
    - Discrete.
    - Continuous.
    - Frequency, relative frequency, and percentage.
4. Cumulative frequency and cumulative relative frequency.
5. Graphical representations:
    - Bar chart.
    - Pie chart.
    - Stem-and-leaf plot
    - Histogram.
6. Measures of central tendency.
7. Measures of dispersion:
    - Range.
    - Variance and standard deviation.
    - Coefficient of variation.
    - Shape characteristics.

Chapter 2: Statistical Series with Two Variables (1 Week)

1. Covariance.
2. Linear correlation coefficient.
3. Linear regression.
4. Regression line (Y on X).

Part B: Probability

Chapter 3: Combinatorial Analysis (1 Week)

1. Arrangements.
2. Combinations.
3. Permutations.

Chapter 4: Introduction to Probability (3 Weeks)

1. Operations on events.
2. Definitions. Probability spaces.
3. General probability theorems.
4. Conditional probability. Independence.
5. Total probability. Bayes' theorem.

Chapter 5: Discrete Random Variables (1 Week)

1. Definitions and properties.
2. Distribution function.
3. Mathematical expectation.
4. Covariance and moments.

Chapter 6: Common Discrete Probability Distributions (1 Week)

1. Bernoulli distribution.
2. Binomial distribution.
3. Poisson distribution.

Chapter 7: Continuous Random Variables (1 Week)

1. Definitions and properties.
2. Probability Density Function.
3. Cumulative Distribution Function.
4. Mathematical expectation.
5. Covariance and moments.

Chapter 8: Common Continuous Probability Distributions (2 Weeks)

1. Uniform distribution.
2. Normal distribution.
3. Exponential distribution.

Assessment Method:

- Written quizzes.
- Homework assignments.
- Final examination.

Bibliographic References:

1. Bertsekas, D. P., & Tsitsiklis, J. N. (2008). Introduction to Probability. Athena Scientific.
2. Devore, J. L. (2015). Probability and Statistics for Engineering and the Sciences. Cengage Learning.
3. Durrett, R. (2009). Elementary Probability for Applications. Cambridge University Press.
4. Johnson, R. A., & Bhattacharyya, G. K. (1996). Statistics: Principles and Methods. Wiley.
5. Ross, S. M. (2014). A First Course in Probability. Pearson.
6. Ross, S. M. (2014). Introduction to Probability and Statistics for Engineers and Scientists. Academic Press.
7. Wackerly, D., Mendenhall, W., & Scheaffer, R. L. (2007). Mathematical Statistics with Applications. Cengage Learning.

Semester: 01
Teaching Unit: Transversal Unit
Course title :: Critical Thinking & Problem Solving
Lecture Hours: 1h30 Lecture
Credits: 1
Coefficient: 1
Course Objectives:

Comité Pédagogique National du Domaine Sciences de la Matière CPND-SM

Ce module d'origine nord-américaine (inspiré par Ontario Tech University) vise à structurer la pensée scientifique des étudiants pour les armer face à la complexité des systèmes d'IA et de physique moderne.

Course Content:

Chapter 1: Introduction to Critical and Scientific Thinking (2 Weeks)

- Definition of critical thinking.
- Difference between:
  - opinion,
  - belief,
  - hypothesis,
  - scientific fact.
- Introduction to the scientific method.
- Main cognitive biases:
  - confirmation bias,
  - anchoring bias,
  - Dunning–Kruger effect.

Objective:
Train students to recognize errors in reasoning.

Chapter 2: Logic and Argument Analysis (2 Weeks)

- Structure of an argument:
  - premises,
  - conclusion,
  - inference.
- Deductive and inductive reasoning.
- Main logical fallacies:
  - ad hominem,
  - hasty generalization,
  - false causality.

Activity:
Simplified critical analysis of a scientific or media text.

Chapter 3: Problem-Solving Methodology (3 Weeks)

Method:

1. Understand the problem.
2. Design a strategy.
3. Execute the solution.
4. Verify the results.

Applications:

- simple scientific problems,
- algorithms,

- basic physics.

Tools:

- simple diagrams,
- decomposition of a complex problem.

Chapter 4: Systems Thinking and Root Cause Analysis (3 Weeks)

- Introduction to systems thinking.
- Feedback loops.
- Root Cause Analysis (RCA).
- The Five Whys method.
- Ishikawa diagram.
- Pareto principle.

Applications:

- software bugs,
- experimental failures,
- data errors.

Chapter 5: Scientific Creativity and Innovation (2 Weeks)

- Introduction to lateral thinking.
- Simple creativity techniques.
- Creative resolution of technical contradictions.
- Simplified introduction to TRIZ.

Case Study:

Solving a simple engineering problem.

Chapter 6: Scientific Communication and Ethics (2 Weeks)

- Structuring a scientific argument.
- Logical presentation of a problem.
- Introduction to the Minto Principle.
- Fundamentals of scientific and AI ethics.

Guided Debate:

- AI bias,
- algorithmic responsibility.

Week 15: Presentations and Mini-Projects

Integrative Mini-Project:

- analysis of a real-world problem,
- application of the tools studied,
- short oral presentation.

Detailed syllabus by subject for Semester 2

Semester 2
Course title : Algebra 2
Teaching Unit : Fundamental
Credits 6
Coefficient 3

Course Objectives
This course develops advanced linear algebra concepts essential for quantum computing, quantum mechanics, and artificial intelligence. Particular emphasis is placed on Hermitian spaces, operators, spectral theory, and quantum state representation.
Recommended Prerequisite Knowledge
Algebra 1.
Course Content
Chapter 1: Linear Transformations and Matrix Algebra (3 Weeks)
- Linear transformations.
- Kernel and image.
- Rank theorem.
- Matrix representation.
- Matrix operations.
- Invertible matrices.
- Change of basis.
- Similar matrices.

Chapter 2: Determinants and Linear Systems (2 Weeks)
- Determinants and properties.
- Cofactors.
- Cramer systems.
- Matrix rank.
- Numerical stability of systems.

Chapter 3: Eigenvalues and Diagonalization (3 Weeks)
- Eigenvalues and eigenvectors.
- Characteristic polynomial.
- Cayley–Hamilton theorem.
- Diagonalization.
- Matrix powers.
- Applications to dynamical systems.

Chapter 4: Inner Product and Hermitian Spaces (3 Weeks)
- Inner products.
- Hermitian products.
- Norms and distances.
- Orthogonality.
- Orthonormal bases.
- Gram–Schmidt orthogonalization.
- Orthogonal projections.

Chapter 5: Hermitian and Unitary Operators (4 Weeks)
- Hermitian operators.
- Unitary operators.
- Spectral theorem.
- Projection operators.

Assessment Method

- Final Examination.
- Continuous Assessment.

References

1. Axler, Linear Algebra Done Right.
2. Strang, Linear Algebra and Its Applications.

Semester 2
Course title : Analysis 2
Teaching Unit : Fundamental
Credits 6
Coefficient 3
Course Objectives
This course introduces integral calculus, differential equations, multivariable analysis, and optimization methods used in physics, quantum systems, machine learning, and scientific computing.

Recommended Prerequisite Knowledge
Analysis 1.
Course Content
Chapter 1: Integral Calculus (3 Weeks)
- Indefinite integrals.
- Integration techniques:
  - substitution,
  - integration by parts,
  - rational functions.
- Definite integrals.
- Newton–Leibniz theorem.

Chapter 2: Differential Equations (4 Weeks)
- First-order differential equations:
  - separable equations,
  - linear equations,
  - Bernoulli equations.
- Second-order differential equations with constant coefficients.
- Oscillatory systems.
- Exponential growth and decay.
- Physical and computational applications.

Chapter 3: Multivariable Functions (4 Weeks)
- Functions of several variables.
- Partial derivatives.
- Gradient and directional derivatives.
- Jacobian matrix.
- Optimization of multivariable functions.

Chapter 4: Sequences and Series of Functions (3 Weeks)
- Functional sequences.
- Uniform convergence.
- Power series.
- Fourier series (introduction).
- Complex exponential representation.

Chapter 5: Introduction to Orthogonal Polynomials (1 Week)
- Definition of Orthogonality.
- Legendre Polynomials.
- Hermite Polynomials.
- Laguerre Polynomials.

Assessment Method
- Final Examination.

- Continuous Assessment.

References

1. Rudin, Principles of Mathematical Analysis.
2. Boyce & DiPrima, Differential Equations.
3. Kreyszig, Advanced Engineering Mathematics.
4. Kreyszig, E. (2010). Advanced Engineering Mathematics 10E. John Wiley & Sons.
5. Boyce, W. E., DiPrima, R. C., & Meade, D. B. (2022). Elementary differential equations and
6. boundary value problems (12th ed.). John Wiley & Sons.
7. Boas, M. L. (2009). Mathematical methods in the physical sciences. John Wiley & Sons.
8. Arfken, G. B., Weber, H. J., & Harris, F. E. (2012). Mathematical methods for physicists: A
9. comprehensive guide (7th ed.). Academic Press.
10. Apostol, T. M. (2019a). Calculus, volume 1 (2nd ed.). Wiley.
11. Apostol, T. M. (2019b). Calculus, volume 2 (2nd ed.). Wiley.

Semester: 02
Teaching Unit: Fundamental
Course title : Electricity and Magnetism
Credits: 6
Coefficient: 3

Course Description

This course provides students with the foundational concepts and principles of electricity and magnetism. Topics include electrostatics, conductors, direct-current (DC) circuits, magnetostatics, and magnetic induction. Emphasis is placed on both theoretical understanding and practical problem-solving skills relevant to physical science and engineering applications.

Learning Outcomes

By the end of this course, students will be able to:

- Apply Coulomb's law and Gauss's theorem to calculate electric fields and potentials.
- Analyze electrostatic properties of conductors and capacitors, including capacitance calculations.
- Solve direct-current circuit problems using Ohm's law, Joule's law, and Kirchhoff's laws.
- Explain magnetostatic phenomena and apply the Biot–Savart law and Ampère's law to compute magnetic fields.

Weekly Topics and Schedule

Weeks 1–3: Electrostatics

- Electric charge and electric fields
- Electrostatic potential
- Electric dipoles
- Electric flux
- Gauss's theorem

Weeks 4–5: Conductors

- Definition and properties of conductors in electrostatic equilibrium
- Electrostatic stress
- Capacitance of conductors and capacitors

Weeks 6–8: Direct-Current (DC) Circuits

- Electrical conduction
- Ohm's law
- Joule's law
- Basic electrical circuits
- Application of Ohm's law to networks
- Kirchhoff's laws

Weeks 9–11: Magnetostatics

- Lorentz force
- Laplace's law
- Biot–Savart law
- Magnetic dipoles

Weeks 12–15: Magnetic Induction

- Fundamental principles and applications (details covered in lectures and tutorials)
- Understand and apply the principles of magnetic induction to basic physical systems.

Assessment Methods

- **Continuous Assessment:** 33% (quizzes, assignments, participation in tutorial sessions)
- **Final Exam:** 67% (comprehensive written exam)

References

1. Purcell, E. M. (2013). Electricity and Magnetism. United Kingdom: Cambridge University Press.

2. Halliday, D., Resnick, R., Walker, J. (2021). Fundamentals of Physics, Volume 2. United Kingdom: John Wiley & Sons, Limited.
3. Young, H. D., Freedman, R. A. (2019). University Physics, Volume 2 (Chapters 21-37), Global Edition. United Kingdom: Pearson Education, Limited.
4. Jewett, J. W., Serway, R. A. (2008). Physics for Scientists and Engineers. United Kingdom: Thomson Brooks/Cole.
5. Giancoli, D. C. (2008). Physics for Scientists & Engineers with Modern Physics. United States: Pearson Prentice Hall.
6. Feynman, R. P., Leighton, R. B., Sands, M. (2011). The Feynman Lectures on Physics, Vol. II: The New Millennium Edition: Mainly Electromagnetism and Matter. Basic Books.

Semester: 02
Teaching Unit: Methodology Unit
Course title : Electricity and Electromagnetism Lab Sessions
Credits: 6
Coefficient: 3

Course Description
This laboratory course consolidates the theoretical knowledge acquired in the Electricity and Magnetism corse and develops practical skills in experimental techniques. Students will learn how to set up, operate, and interpret measurements in various electrical experiments, enabling them to visualize and better understand the phenomena studied in lectures and tutorials.
Learning Outcomes
By the end of this course, students will be able to:
1. Perform accurate measurements of electric fields and potentials using laboratory instruments.
2. Construct and analyze basic electrical circuits, applying Ohm's law and measuring resistance.
3. Use the Wheatstone bridge method for precise resistance measurement.
4. Operate oscilloscopes and signal generators, including transformer-based systems.
5. Measure and analyze the behavior of capacitors, including series/parallel combinations and charge–discharge cycles.
6. Verify the Biot–Savart law experimentally.
7. Determine the Earth's magnetic field using appropriate apparatus.

Lab Schedule and Topics
Electrical Lab
1- **Measurement of electric field and potential (rheographic tank)**
2- **Measurement of resistances and verification of the laws of combination** : association and measurement of resistances
resistance measurement using the wheatstone bridge and a wire bridge. wheatstone bridge
3- **Charging And Discharging A Capacitor :** Study of the charging and discharging of a capacitor and verification of capacitor association laws.
4- **Use Of The Oscilloscope And Phase Shift Measurement :** Measurement of phase shifts between different electronic components (resistor-capacitor-inductor) in AC operation, as well as the study of resonance in the R-L-C circuit.
5- **Magnetic Field Generated By A Circular Loop As Well As The Helmoltz Coil :** Measurement and study of the properties of the magnetic field generated by a circular loop as well as that generated by the Helmholtz coil. Measurement of Earth's magnetic field

References

- Caubarrere, J. L., *Electricity and Waves: Lectures and Lab Sessions*. OPU, Algiers (1986).
- Bentounsi, A., *General Electricity, Vol. 2: Solved Exercises*. OPU, Algiers (1992).
- Ediscience Collective, *University Physics: Electrostatics and Direct-Current Circuits, Years 1 and 2*. Ediscience International (2010).
- Fedullo, D., Gallauziaux, T., *Electricity: How to Build Your Own Electrical Installation*. Eyrolles (2012).
- Largeaud, H., *Electrical Schematics*. Eyrolles (2006).

Semester: 02
Teaching Unit: Methodology Unit
Course title : Computer Organization 2
Credits 3
Coefficient 2
Course Objectives
This course develops the foundations of modern computer architecture and introduces students to processor organization, assembly language, memory systems, and introductory microarchitecture concepts. The course bridges digital logic with modern computational systems relevant to Quantum Computing and Quantum Technologies.

Recommended Prerequisite Knowledge
- Computer Organization 1.
- Basic programming skills in Python or C.

Course Content

Chapter 1: Sequential Systems and Finite State Machines (2 Weeks)
- Synchronous systems.
- Timing concepts:
  - setup time,
  - hold time,
  - clock synchronization.
- Finite State Machines:
  - Moore automata,
  - Mealy automata.
- State transition diagrams.
- FSM implementation and applications.

Chapter 2: Introduction to Computer Architecture (2 Weeks)
- Basic computer organization.
- CPU architecture overview.
- Datapath and control unit.
- Von Neumann architecture.
- RISC vs. CISC architectures.
- Introduction to RISC-V philosophy.

Chapter 3: Assembly Language Fundamentals (3 Weeks)
- Machine language and assembly language.
- Registers and memory organization.
- Arithmetic and logical instructions.
- Conditional branches and loops.
- Procedures and function calls.
- Stack fundamentals.
- Introduction to low-level debugging using RARS simulator.

Chapter 4: Processor Datapath and ALU Design (3 Weeks)
- Arithmetic Logic Unit (ALU).
- Datapath components:
  - registers,
  - multiplexers,
  - buses,
  - memory blocks.
- Single-cycle processor concept.
- Instruction execution cycle:

    - fetch,
    - decode,
    - execute,
    - memory access,
    - write-back

Chapter 5: Memory Systems and Cache Introduction (2 Weeks)

- Main memory organization.
- SRAM vs. DRAM.
- Cache memory principles.
- Temporal and spatial locality.
- Introduction to cache performance.
- Memory hierarchy overview.

Chapter 6: Introduction to Pipelining and Parallelism (1 Week)

- Motivation for pipelining.
- Pipeline stages.
- Basic hazards:
    - structural,
    - data,
    - control hazards.
- Introduction to multicore and parallel architectures.
- GPU and SIMD concepts (overview).

Chapter 7: Introduction to Quantum Hardware Concepts (1 Week)

- Classical vs. quantum hardware.
- Qubit control electronics.
- Cryogenic computing overview.
- FPGA and control systems (introductory concepts).
- Future quantum processor architectures.

Practical Work / Laboratories

- FSM implementation.
- Assembly programming with RARS.
- Simple datapath simulation.
- Cache simulation exercises.
- Basic processor architecture project.
- Introductory pipeline simulation.

Recommended Tools

- Logisim Evolution.
- JFLAP.
- RARS (RISC-V Assembler and Runtime Simulator).
- Digital simulator.
- Optional introduction to nand2tetris tools.

Assessment Method

- Final Examination.
- Continuous Assessment.
- Laboratory reports.
- Mini-project or architecture design assignment.

References

1. David Harris & Sarah Harris, Digital Design and Computer Architecture.
2. Patterson & Hennessy, Computer Organization and Design.
3. Bryant & O'Hallaron, Computer Systems: A Programmer's Perspective.

4. Nand2Tetris Course Materials.
5. RISC-V Reader.

Semester 2
Course title : Algorithmics 2
Teaching Unit : Methodology
Credits : 4
Coefficient : 2
Course Objectives
This course develops intermediate programming skills and introduces essential algorithmic structures, scientific computation methods, and introductory data organization concepts relevant to Quantum Computing and Quantum Technologies, artificial intelligence, and computational sciences.
Recommended Prerequisite Knowledge

- Algorithmics 1.

Course Content
Chapter 1: Advanced Functions and Recursion (2 Weeks)

- Recursive algorithms.
- Recursive vs. iterative approaches.
- Algorithm decomposition.
- Problem-solving strategies.

Chapter 2: Fundamental Data Structures (3 Weeks)

- Stacks.
- Queues.
- Linked lists (conceptual introduction).
- Dictionaries and associative arrays.
- Dynamic data structures (introductory concepts).

Chapter 3: File Handling and Data Processing (2 Weeks)

- Reading and writing files.
- CSV and text processing.
- Structured data manipulation.
- Introduction to data preprocessing.

Chapter 4: Algorithmic Problem Solving (3 Weeks)

- Searching algorithms:
  - linear search,
  - binary search.
- Sorting algorithms:
  - selection sort,
  - insertion sort,
  - bubble sort.
- Complexity intuition:
  - $O(n)$,
  - $O(\log n)$,
  - $O(n^2)$.

Chapter 5: Introduction to Numerical and Matrix Computing (2 Weeks)

- NumPy arrays.
- Matrix operations.
- Numerical precision.
- Random number generation.
- Introduction to vectorized computation.

Chapter 6: Introduction to Data Visualization and Simulation (3 Weeks)

- Scientific visualization with Matplotlib.
- Simple physical simulations.

- Computational modeling concepts.
- Visualization of algorithm behavior.

Practical Work / Laboratories

- Python algorithm implementation.
- Matrix computation exercises.
- Numerical simulation mini-projects.
- Data visualization exercises.
- Introductory scientific computing projects.

Recommended Tools

- Python.
- Jupyter Notebook.
- NumPy.
- Matplotlib.
- VS Code or Spyder.

Assessment Method

- Final Examination.
- Continuous Assessment.
- Laboratory reports.
- Computational mini-projects.

References

1. Allen Downey, Think Python.
2. Thomas H. Cormen, Introduction to Algorithms.
3. Wes McKinney, Python for Data Analysis.
4. Jake VanderPlas, Python Data Science Handbook.

Semester: 02
Teaching Unit: Discovery
Course Title: General chemistry
Credits: 1
Coefficient: 1

Course Description

This course provides an introduction to atomic and molecular electronic structure, chemical bonding, thermodynamics, equilibrium, oxidation-reduction chemistry, chemical kinetics, and catalysis.

Prerequisites

High-school chemistry. Elementary algebra and calculus.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Explain atomic structure and chemical bonding using elementary quantum-mechanical concepts.
2. Relate molecular structure to the physical and chemical properties of matter.
3. Apply thermodynamic and equilibrium principles to chemical systems.
4. Analyze oxidation-reduction processes and basic electrochemical phenomena.
5. Apply kinetic concepts to describe chemical reactions and catalysis.

Course Content:

Chapter 1: THE ATOM (3 weeks)

Introduction to chemical science; atomic theory; hydrogen atom; multi-electron atoms; periodic properties.

Chapter 2: CHEMICAL BONDING AND STRUCTURE (4 weeks)

Lewis structures; molecular geometry; covalent bonding; molecular orbital theory; hybridization; intermolecular forces.

Chapter 3: THERMODYNAMICS AND CHEMICAL EQUILIBRIUM (3 weeks)

First law of thermodynamics; entropy; Gibbs free energy; chemical equilibrium.

Chapter 4: OXIDATION-REDUCTION AND ELECTROCHEMISTRY (2 weeks)

Oxidation-reduction reactions; introduction to electrochemistry.

Chapter 5: V – CHEMICAL KINETICS (3 weeks)

Reaction rates; rate laws; Arrhenius equation; elementary catalysis.

Recommended Textbook

1. Atkins, P. W., & Jones, L. *Chemical Principles: The Quest for Insight* (5th ed.). W. H. Freeman, 2010.
2. Atkins, P., de Paula, J., & Keeler, J. *Atkins' Physical Chemistry* (12th ed.). Oxford University Press, 2022.
3. Brown, T. L., et al. *Chemistry: The Central Science* (14th ed.). Pearson, 2018.
4. MIT OpenCourseWare. *5.111SC Principles of Chemical Science*. Massachusetts Institute of Technology, 2014. https://ocw.mit.edu/courses/5-111sc-principles-of-chemical-science-fall-2014/pages/syllabus/

Semester: 01
Teaching Unit: Transversal Unit
Course title: Introduction to Scientific Writing, LaTeX and Linux environment
Credits: 2
Coefficient: 2

Course Description:

This course introduces students to the modern tools used in scientific research and technical communication. Students learn how to install and use Linux operating systems, work from the command line, prepare scientific documents using LaTeX, and employ modern AI tools responsibly for scientific writing and document preparation. Emphasis is placed on open-source software, scientific publishing, and ethical use of artificial intelligence.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

- Install and configure a Linux operating system.
- Use Linux command-line tools.
- Manage files, users, and software packages.
- Create scientific documents with LaTeX, including typeset mathematical formulas, tables and figures and manage bibliographic references.
- Prepare scientific presentations with Beamer.
- Use AI assistants to generate and improve LaTeX documents.
- Evaluate and verify AI-generated scientific content.

Course contents:

Chapter 1 Scientific Communication and Publication

1.1 Scientific Publications • Research articles • Technical reports • Conference proceedings • Theses and dissertations	1.2 Structure of a Scientific Paper • Title • Abstract • Introduction • Methods • Results • Discussion • Conclusion • References	1.3 Scientific Ethics • Plagiarism • Citation practices • Responsible use of AI

Chapter 2 Linux Installation and Operating Systems

2.1 Introduction to Open-Source Software	**2.2 Linux Distributions Beginner-Friendly**	**2.3 Installing Linux**
• Free software philosophy • GNU project • Linux kernel	• Ubuntu • Linux Mint • Zorin OS Scientific and Educational • Debian • Fedora Advanced • Arch Linux • OpenSUSE	• Live USB creation • Dual boot installation • Disk partitioning • UEFI and BIOS • Bootloaders • Software installation Practical: • Install Ubuntu Linux in a virtual machine. • Create a dual-boot • system.

Chapter 3 Linux Fundamentals

3.1 Linux File System	3.2 Essential Commands	3.3 Text Processing	3.4 Permissions and Users
• Directories • Absolute and • relative paths	• pwd • ls • cd • mkdir • cp • mv • rm • find	• cat • less • grep • sort • wc • head • tail	• chmod • chown • groups • sudo

Chapter 4 Shell Scripting and Automation

4.1 Bash Basics	4.2 Automation
• Variables • Input/output • Loops • Conditions	• Batch processing • Data management • Script execution

Chapter 5 Introduction to LaTeX

5.1 Why LaTeX?	5.2 Document Structure
• Scientific publishing • Comparison with word processors	• Document classes • Packages • Sections • Lists

Chapter 6 Mathematics and Scientific Typesetting

6.1 Mathematical Expressions	6.2 Advanced Mathematics	6.3 Scientific Notation
• Inline mathematics • Display mathematics • Equation numbering	• Matrices • Cases • Align environment	• Units • Symbols • Theorems

Chapter 7 Figures, Tables and Graphics

7.1 Tables	7.2 Figures	7.3 TikZ Graphics	7.4 Cross Referencing
• tabular • longtable	• includegraphics • Float environments	• Scientific diagrams • Simple plots	• labels • references • hyperlinks

Chapter 8 Bibliography and Scientific Publishing

8.1 BibTeX

8.2 BibLaTeX

8.3 Citation Styles

- APA
- IEEE
- Physical Review

8.4 Journal Templates

- APS
- Elsevier
- Springer

Chapter 9 Scientific Presentations with Beamer

9.1 Creating Presentations

9.2 Themes

- Metropolis
- Madrid
- Cambridge

9.3 Mathematical Presentations

9.4 Figures and Animations

Chapter 10 AI-Assisted Scientific Writing and LaTeX

10.1 Introduction to AI Assistants

Examples:

- ChatGPT
- Claude
- Gemini
- Copilot
- Deepseek

10.2 Generating LaTeX with AI

- Reports
- Articles
- Presentations
- Tables

10.3 AI-Assisted Literature Review

- Searching literature
- Summarization
- Reference extraction

10.4 Verification of AI Output

- Detecting errors
- Hallucinations
- Mathematical verification

10.5 Ethical and Responsible Use

- Transparency
- Attribution
- Academic integrity

10.6 AI and Reproducible Research

- Human supervision
- Generate a complete article with AI assistance.
- Generate Beamer slides using AI.
- Correct AI-generated LaTeX errors.
- Evaluate AI-generated scientific content.

Chapter 11 Git Fundamentals

11.1 Installation

- Linux

- Windows
- macOS

Essential Commands (git init, git clone, git add, git commit, git status, git log)

11.2 Remote Repositories

(GitHub , GitLab, Bitbucket)

Topics:

- Repository creation

- Cloning projects

- Synchronization

Commands: (git push, git pull, git fetch)

Assessment Method:

• Final Exam

• Continuous Assessment

Recommended References:

1. Linux : The Linux Command Line — William Shotts
2. LaTeX
   - LaTeX: A Document Preparation System — Leslie Lamport
   - Guide to LaTeX — Kopka and Daly
   - The Not So Short Introduction to LaTeX2e
   - Lamport, L., *LaTeX: A Document Preparation System*, 2nd Edition, Addison-Wesley, 1994.
   - Datta, D., *LaTeX in 24 Hours: A Practical Guide for Scientific Writing*, Springer, 2017.

AI for Research

1. Nature and Science guidelines on the use of generative AI in research and publishing.
2. Git : Pro Git —Scott Chacon and Ben Straub

URL: https://git-scm.com/book/en/v2