# Department of Materials Science and Technology

**Maulana Abul Kalam Azad University of Technology, West Bengal**

**(Formerly West Bengal University of Technology)**

**Haringhata-741249, Nadia, West Bengal, INDIA**

**Maulana Abul Kalam Azad University of Technology, West Bengal**
*(Formerly West Bengal University of Technology)*
**Department of Materials Science and Technology**
**BACHELOR OF SCIENCE IN MATERIALS SCIENCE**
**Effective from academic session 2023-24**

## Preamble:

Department of Materials Science and Technology under the School of Natural and Applied Sciences of Maulana Abul Kalam Azad University of Technology West Bengal (MAKAUT WB) is introducing a three years Bachelors Course in Materials Science (BSc- Materials Science), with an **emphasis on computational techniques associated with Materials Science and Technology and Nanomaterials**. The under graduate syllabus has been designed following the recommendations and guidelines of University Grants Commission (UGC) according to the Semester Wise Choice Based Credit System (CBCS) scheme. The contents, structure and date of effect of the proposed syllabus has been decided by the board of studies (B.O.S) of the department following its acceptance and approval. Meeting held on 20th Nov, 2019 at Department of Materials Science and Technology, MAKAUT WB (Haringhata Campus).

## Purpose:

The B.Sc. Course is systematically designed where students shall be trained on the fundamentals of Physics, Chemistry Mathematics, and Computational Techniques required for understanding and designing of materials. During framing of this syllabus for B.Sc. (Honours) in Materials Science, substantial weightage has been given in both the core subjects as well as skill and ability enhancement of the students. The ultimate goal of the syllabus is to enable the students to have an in-depth knowledge of the subject/s and enhance their scope of employment in the industry. **The program shall also enable students to develop a deep understanding of various aspects of computational materials science**.

Special care shall be taken for developing entrepreneurship capacity building and excellent opportunity shall be provided to improve extra-curricular and leadership skills.

The final year project is a key part of the curriculum, this can be chosen from a variety of topics given to the students or even students may implement their ideas into practice. Students will get to work on exciting research ideas ranging from designing/synthesis of materials to applications both by experimental and computational techniques.

The summers are about giving an exposure to practice materials research through mini-projects, as well as industrial visits.

Hope the proposed curriculum will make it more contextual, viable and suitable to cater the needs of students of Materials Science

**Eligibility Criteria**: 10+2 Pass-out from any board with a combination of Physics/Chemistry and Mathematics/Statistics/Computer Science along with other subject combination. Cut-off marks will be decided by the competent authority time to time as per requirement.

**Duration of the Course:** 4 years

**Student Intake: 30**

## Program Outcome

Upon completion of this 3-year Under-Graduate degree program, the students will be able to:

| Program Outcome |
|---|
| **PO1.** Understand the relationship between structure, property, processing and performance of materials with basic concepts of physics and chemistry associated with Materials Science |
| **PO2.** Work like professional scientists and engineers and develop creative and entrepreneurship skills along with computational skill |
| **PO3.** Develop their knowledge about the fundamentals of materials design and selection and their industrial application |
| **PO4.** Use the concepts of statistics which would help to handle large data in Materials Science and apply mathematical skills to solve material science problems computationally |
| **PO5.** Build a strong research aptitude in the field of materials science and helps them to present their ideas and summarize their findings in written and oral reports |
| **PO6.** Know the importance of natural resources and the need for their preservation |
| **PO7.** To acquire experimental skills associated to Materials Science |

## SEMESTER I

### BMS101: Introduction to Materials — L-T-P: 3-1-0 (Credit - 3)

**Course Objectives:**

This course will introduce basic concepts of materials around us, different types of materials. This course will help to understand the science behind the formation of material, evolution of materials science and the structure property correlation.

**Course Content**

1. Evolution of material science: Understanding the Materials around us and the science behind the material, Structure property correlation, Advanced Materials, Modern Materials Need. Materials for Engineering Applications., Processing/Structure/Properties/Performance Correlations, Case Study: Importance of different materials to be discovered. **Offline 12L**

2 Electronic energy band theory, classical free electron theory of solids, Sommerfeld quantum free electron theory of a solid, Bloch wave-functions for a periodic potential, Kronig-Penny model and energy bands. Fermi energy and Fermi surfaces, effective mass of an electron, Brillouin zones & Reciprocal lattice. Many electron theories. **Online 10L**

**3.** Crystal Structure and Lattice Imperfections: Bravais lattices, Symmetry, Bragg's Law, Different types of crystal structure, Atomic Packing Factor. Packing density, Hexagonal close packed structure, Coordination number, Point defect. Line defect. Surface Defect. Volume defect. **Online 8L**

**4.** Classification of Materials: Level of Structure, Metallic Alloys, Ceramic Materials, Polymeric Materials, Magnetic Materials, Electronic Materials. **Offline 8L**

**5.** Properties of Materials: Introduction to different types of properties of Materials, Bar-chart of properties of material. their physical properties, and selection. Brief introduction to properties of materials, Mechanical property, Concept of stress and strain, elastic and plastic deformation, hardness, Electrical property, ohm's law, electronic and ionic conduction, energy band structure, intrinsic and extrinsic semiconductor, Thermal property, thermal conductivity and thermal diffusivity. **Online 10L**

**Suggested readings:**

1. Materials Science and Engineering – William D. Callister, Jr
2. Materials Science and Engineering, A First Course – V. Raghavan
3. Materials Selection in Mechanical Design, 2nd Ed., Ashby (Butterworth/Heinemann, 1999)
4. Animalu – Intermediate Quantum Theory of Crystalline Solids

| Sl. No | **Course Outcome:** On successful completion of this course, student should be able to |
|---|---|
| 1 | To know the evolution of materials science and understanding materials around us |
| 2 | Understanding the materials structure property relationship that are involved in the design, production, and utilization of materials |
| 3 | Be able to describe the electronic band structure of materials, free electron theory and able to describe the relation between electrical and thermal conductivity of materials |

**CO-PO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 1 | 2 | - | 2 |
| CO2 | 3 | 2 | 3 | 1 | 3 | - | 2 |
| CO3 | 3 | 2 | 3 | 1 | 3 | - | 2 |

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

## BMS102: Statistical Methods for Materials Science

**L-T-P: 3-1-0 (Credit - 3)**

**Course Objectives:**

The objective of the course is to enable the students to understand basic statistics and probability distribution which would help to handle large data set in Materials Science. The course will make students proficient with solving statistical problems using tool like MATLAB, excel

**Course Content**

**1. Introduction to Statistics:** Definition of Statistics. Basic objectives. Applications in various branches of science with examples. Collection of Data: Internal and external data, Primary and secondary Data. Population and sample, Complete enumeration and sample survey, Chart and Diagrams **Offline 10 L**

**2. Descriptive Statistics**: Univariate Data: Measures of central tendency, Dispersion and shape, Classification and tabulation of univariate data, graphical representation, Frequency curves. Bivariate data: Scatter diagram, Marginal and conditional frequency distribution. Correlation and Regression **Online 14 L**

**3. Introduction to Probability:** Concept of experiments, sample space, event. Definition of Combinatorial Probability. Conditional Probability, Bayes' Theorem. Axioms, Interpretations, and Properties of Probability **Online 10 L**

**4. Introduction to Probability distributions**: discrete & continuous distributions, Binomial, Poisson and Geometric distributions, Uniform, Exponential, Normal, Weibull Distribution, Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the Multinomial distribution, Poisson approximation to the Binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality. **Online 10L**

**5. Sampling Techniques**: Random Sampling. Sampling from finite and infinite populations. Estimates and standard error (sampling with replacement and sampling without replacement), Sampling distribution of sample mean, stratified random sampling. **Offline 10L**

**6. Estimation and Hypothesis testing.** Multivariate Data Analysis, Maximum likelihood estimate. Coefficient of determinant, R square, Residual Analysis, Chi square, p-value, Test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes. **Offline 8L**

**Suggested readings:**

1. S. M. Ross, "A first course in Probability", Prentice Hall.
2. I. R. Miller, J.E. Freund and R. Johnson, "Probability and Statistics for Engineers". Fourth Edition, PHI.
3. A. M. Mood, F.A. Graybill and D.C. Boes, "Introduction to the Theory of Statistics", McGraw Hill Education.

| Sl. No | **Course Outcome:** On successful completion of this course, student should be able to |
|---|---|
| 1 | Analyze statistical data graphically using frequency distributions and cumulative frequency distributions. And able to solve regression problems |
| 2 | Use the basic probability rules, including additive and multiplicative laws, to solve problems related to materials science |
| 3 | Use different sampling techniques to solve the problems associated to materials science |

**CO-PO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| CO1 | 1 | 2 | 3 | 3 | 2 | - | 2 |
| CO2 | 1 | 2 | 3 | 3 | 3 | - | 2 |
| CO3 | 1 | 2 | 3 | 3 | 3 | - | 2 |

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

## Laboratory I: Macroscopic and Microscopic Examination of Materials (BMS191)

**L-T-P: 0-0-4 (Credit - 2)**

1. Macroscopic observation of different materials around us.
2. Microscopic observation of different materials around us
3. Mechanical property evaluation of different types of materials
4. Electrical resistivity evaluation of different types of materials
5. Thermal property evaluation of different types of materials

**LEARNING RESOURCES:**

1. An advanced course in practical physics, Chattapadhyay and Rakshit.
2. Advanced practical Physics, K. G. Mazumdar.

## Laboratory II: Introduction to Programming using C and MATLAB (BMS192)

**L-T-P: 0-0-4 (Credit - 2)**

**Basic programming in C**

(a) Introduction to Computers. Computer Systems, Computing Environments, Flow charts. Number Systems: Binary, Octal, Decimal, Hexadecimal Introduction to C Language - Background, C Programs, Identifiers, Data Types, Variables, Constants, Input /Output Statements
(b) Operation and Expressions - Arithmetic operators, relational & logical operators.
(c) Decision Making and Branching. Decision making and Looping
(d) Pointers for Inter-Function Communication, Pointers to Pointers, Compatibility, L value and R value, Arrays and Pointers, Pointer Arithmetic and Arrays, Passing an Array to a Function, Memory Allocation Functions, Array of Pointers, Programming Applications, Pointers to void, Pointers to Functions, Command. Line Arguments. Strings - Concepts, C Strings, String Input/Output Functions, Arrays of Strings, String Manipulation Functions
(e) List of practical: Write a C program:

1. To display your name.
2. For addition of two numbers and display the result.
3. To find maximum between two numbers
4. To check whether a number is divisible by 3 and 7 or not
5. Addition of first 10 natural numbers using while loop
6. To find the factorial of given number
7. To print the Fibonacci series in a given range using recursion.

**Basic knowledge of MATLAB**

(1) Introduction and Basic operations in MATLAB
(2) Familiarization of students with the syntax of MATLAB
(3) 2D Plotting of data in MATLAB and statistics problems
(4) Introduction to numerical analysis using C & MATLAB

**LEARNING RESOURCES:**

1. Yashavant Kanetkar, Let us C, 13th Edition BPB Publication
2. E. Balaguruswamy Programming in ANSI C Tata McGraw-Hill
3. Byron Gottfried Schaum's Outline of Programming with C, McGraw-Hill
4. J H Mathews & K D Fink, Numerical Methods Using Matlab

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**SEMESTER –II**

**BMS201: Materials Chemistry** **L-T-P: 3-1-0 (Credit - 3)**

**Course Objectives:** This course will introduce basic concepts of materials chemistry, synthesis, properties and applications of different types of materials. It will discuss electrical properties of ionic solutions and helps in knowing the effect of electrochemical corrosion

**Course Content:**

**1. Basic concepts of Atomic Structure:** Know the states of matter, understand atomic electron energy levels, the associated quantum numbers and their relationship to the periodic table, Mathematical describe a wave, Understand the concept of wave-particle duality of light, descriptively explain the Schrodinger's wave equation, Understand atomic bonding and the formation of bands **Online 14L**

**2. Chemical Bonding:** Hybridization, Introduction to Metal organic frame work, GOF, Organometallic. Use of free energy considerations in metallurgy through Ellingham diagrams, Ionic, dipolar and van Der Waals interactions. **Offline 10L**

**3. Acid Base in Chemistry:** Identify endothermic/exothermic reactions. Discuss reversibility of chemical reactions. Discuss reaction kinetics and rate equations. Explain function of catalyst, Define acids/bases (Lowry-Bronsted and Lewis) and strength of acids/bases and pH, Calculate pH of aqueous solutions, Explain the functionality of a buffer, Calculate enthalpy changes associated with a chemical reaction. **Offline 14L**

**4. Electrochemistry:** Chemistry and electricity, Electrochemical cells, Potential differences at interfaces, Standard half-cell potentials, The Nernst equation, Concentration cells, Analytical applications of the Nernst equation, Determination of solubility products, Potentiometric titrations, Measurement of pH, Membrane potential Electrochemical Corrosion. **Online/Offline 10L**

**LEARNING RESOURCES:**

1. Materials Chemistry: Bradley D. Fahlman, 3rd Edition, Springer
2. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane

**Course Outcomes (COs):** At the end of the course, the student will be able to:

| CO No. | Course outcomes |
|---|---|
| CO-1 | Understand the basics of chemical bonding in terms of atomic structure, quantization and atomic bonding |
| CO-2 | Apply the fundamental concept of bonding and periodic table towards ionic equilibria. The concept of acid base, its classification and applications can be well understood |
| CO-3 | Analyse the correlation between electron transfer and oxidation number. The redox equilibria, electrochemistry is well understood in conjunction with Nernst potential and able to apply for corrosion, electrochemical cell, redox titrations etc. |

**CO-PO Mapping:**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 3 | 1 | 2 | 3 | 2 |
| **CO2** | 3 | 2 | 3 | 1 | 3 | 1 | 3 |
| **CO3** | 3 | 3 | 3 | 2 | 3 | - | 3 |

**Correlation levels 1, 2 or 3 as defined below:**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**BMS202: Mathematics** **Effective from academic session 2023-24**

**L-T-P: 3-1-0 (Credit - 4)**

**Course Objectives:**

This course will introduce students with the concepts of vector algebra, matrices and determinants, linear algebra and complex variables and their properties which would help to use the concept of real-world problems. It will help students to apply mathematical skills in writing mathematical equations to solve material science problems computationally.

**Course Content**

**Vector & Calculus**

**1. Vector Algebra and Calculus:** Recapitulation of Vector Algebra. Idea of linear independence, completeness, basis and representation of vectors. Properties of vectors under rotations. Scalar product and its invariance under coordinate rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. **Offline 6L**

**2. Vector Differentiation:** Scalar and Vector fields. Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. **Online 4L**

**3. Vector Integration:** Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). Application of double integrals to compute Area, Mass, Volume. Application of triple integral to compute volume. **Offline 6L**

**4. Matrices:** Introduction to the idea of a matrix; equality of matrices; special matrices. Algebraic operations of matrices: commutative property, associative property and distributive property. Transpose of a matrix Properties. Symmetric and Skew symmetric matrices. Eigen-values and Eigenvectors. Cayley- Hamilton Theorem. Diagonalization of Matrices. Functions of a Matrix.

Determinants: Properties of determinant (statement only); minor, co-factors and Laplace expansion of determinant; Cramer's rule and its application in solving system of linear equations of three variables.

**Linear Algebra** **Offline/Online 10L**

**5. First Order and Second Order Differential equations**: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. (c) Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. **Online 10L**

**6. Partial Differential Equations:** Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation. **Offline 4L**

**7. Laplace Transform** (LT): Definition; Existence of LT; LT of elementary functions; First and second shifting properties; Change of scale property; LT of derivative of functions. Convolution theorem (statement only). Inverse LT; Solution of ODE's (with constant coefficients) using LT **Offline/ Online 10L**

**8. Complex variables:** Introduction to complex variables, Analytic functions, General Cauchy Theorem, Real-Differentiability and the Cauchy-Riemann Equations. Exponential Function. Harmonic Functions **Online 4L**

**LEARNING RESOURCES:**

**Text Books:**

1. George Arfken and Hans Weber, "Mathematical Methods for Physicists (4th Edition)" Elsevier
2. I. N. Herstein, "Topics in Algebra", John Wiley and Sons.
3. Mary L. Boas, "Mathematical Methods in the Physical Sciences (3rd Edition)
4. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publication, Delhi
5. Calculus Volume I and II, Tom Apostol, John Wiley and Sons Inc.
6. Bartle and Sherbert, Introduction to Real Analysis, Third edition, Wiley-India \item Complex Analysis, V.L Ahlfors, McGraw-Hill Inc.
7. Finite Dimensional Vector Spaces, P. R.Halmos, Springer.
8. Introduction To Matrices And Linear Transformations, D.T. Finkbeiner,Courier Corporation.
9. Linear Algebra, S. Lipschutz and M.L.Lipson, Schaums Outline Series, 2009 McGraw Hill.

**Reference Books:**

1. Gilbert Strang: Introduction to linear algebra
2. Peter V. O'Neil, "Advanced Engineering Mathematics", Seventh Edition, Thomson Learning.
3. M. D. Greenberg, "Advanced Engineering Mathematics", Second Edition, Pearson Education.

**Course Outcomes (COs):**

At the end of the course, the student will be able to:

| CO No. | Course outcomes |
|---|---|
| CO-1 | To Understand the basics of vector algebra, matrices and determinants, linear algebra and complex variables and their properties |
| CO-2 | Apply the fundamental concept of calculus to solve first order, second order and partial differential equations |
| CO-3 | Solve and apply Laplace transformation and learn the introduction of complex variables in Harmonic functions |

**CO-PO Mapping:**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 |
|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 1 | - | 3 | 1 | - | - |
| **CO2** | 2 | 2 | 1 | 3 | 2 | - | - |
| **CO3** | 2 | 3 | 1 | 3 | 3 | - | 1 |

**Correlation levels 1, 2 or 3 as defined below:**

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**Laboratory I: Materials Synthesis Lab (BMS 291)** **L-T-P: 0-0-4 (Credit - 2)**

1. To determine chloride ion in a given water sample by Argentometric method (using chromate indicator solution)
2. Determination of surface tension and viscosity
3. Thin layer chromatography
4. Ion exchange column for removal of hardness of water.
5. Stereochemistry Lab using software ChemDraw, Chem3D Ultra
6. Determination of electrical conductance of different electrolyte solution
7. Determination the strength of different acid and base echant solutions

**Laboratory II: Data Analysis, Visualization and Interpretation using MATLAB (BMS 292)**

**L-T-P: 0-0-4 (Credit - 2)**

1. Basic matrix operations in MATLAB
2. Solution of matrix using MATLAB
2. Various loops and scripts
3. Functions of MATLAB
4. 3D plotting of data of materials science and statistics, mesh, surface, plots with special graphics
5. Application of Programming to solve numerical analysis, Cubic method. Bisection method,
6. Errors in numerical computation, Finite differences, Interpolation
7. Numerical integration and differentiation, Numerical solution of first order differential equations, Systems of linear equations