## Department of Materials Science and Technology offering

**BACHELOR OF SCIENCE**

**IN**

**MATERIALS SCIENCE**

**(Applicable from the academic session 2020-21)**

MAULANA ABUL KALAM AZAD
UNIVERSITY OF TECHNOLOGY,
WEST BENGAL

Utech

*In Pursuit Of Knowledge And Excellence*

# 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**

*Passed in Board of Studies held on 03-04-2023*

# PART – A

# CURRICULUM STRUCTURE

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

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**Department of Materials Science and Technology**

**BACHELOR OF SCIENCE IN MATERIALS SCIENCE**

## Vision of the Department:

To achieve the status of state of art in the field of Materials Science and Technology by creating an exciting, diverse, collaborative and supportive environment for the creation of professionals with environmental consciousness, social, moral and ethical values along with the competency to face the new challenges of rapid technological advancements in the field of Materials Science and Technology.

## Mission of the Department:

- To inculcate ethics, social awareness, morality and responsibility in students to serve the society.
- Nurture and train students for the cutting-edge research fields and technologies based on Materials Science & Technology and other interdisciplinary sciences.
- MST Department is committed to accommodating Materials Science & Technology and allied scientific & technological activities for our learners.
- To develop liaison and collaboration with the globally recognized academic institutions in order to inject new and fresh thinking in teaching, learning and research
- To generate intellectually capable and successful entrepreneurs having environmental consciousness and ethics who can work as an individual or in a group in multi-cultural global environments for continuing significantly towards the betterment of quality of human life.

## About the Department:

Materials have always been the keystone of society and are playing a dominant role in our high-tech age. Modern society is heavily dependent on advanced materials such as lightweight composites for faster vehicles, optical fibers for telecommunications, silicon microchips in this age of miniaturization etc.

The Department of Materials Science and Technology has been established to undertake various academic programme on Materials Science and Technology at different levels. The department is also intended to carry out research activities on materials for enhancing the fundamental knowledge as well as nurturing innovative ideas for designing and developing smart and advanced materials.

## Programs offered by the department

**1. B. Sc in Materials Science (3 years)**

**2. M. Sc in Materials Science (2 years)**

**3. M. Tech in Materials Science and Technology (2 years)**

## About these courses:

These courses span basic to advanced level of physics and chemistry of materials to their mechanical, electrical, magnetic and optical properties and the design, manufacture and applications of metals, alloys, ceramics, polymers, composites, biomaterials, etc. The course curriculum also covers most recent and advanced areas such as Energy harvesting materials, Smart Materials, Materials Data Science and Informatics, Computational Material Science etc.

These courses will provide knowledge on structure, properties, processing and performance of materials. Learners will be able to develop novel computational methodologies and novel routes to address recent challenges on materials design and development.

**Thrust area of research:** Materials Processing and Characterization, Composite materials for electronic and microelectronic components joining, Advanced Materials, Materials for Energy and Sustainability, Design and Development of Materials using Computational Tools, Materials Data Science and Informatics

**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**

**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**.

**Structure of the Course:**

**First year of under-graduate study (Semester I &II):** During the first two semester students shall be exposed with six core courses, giving emphasis on basic sciences and mathematics to teach materials behaviour: atomic bonding, thermodynamics, mechanics, and crystal defects. Along with these core courses, special emphasis shall be given to make students digitally equipped. They will learn to handle **computational software** and tool like **MATLAB along with programming language C, Python.**

**Second year of under-graduate study (Semester III &IV):** The scientific foundation shall be further strengthened by a strong curriculum content consisting of courses in**:** Kinetics of Materials and Transport Phenomena, Materials Behaviour: Mechanical, Electrical & Magnetic, Structure of Materials and processing of materials. A vibrant set of skill enhancement elective (Basics of Artificial Intelligence; Basics of Block Chain Technology, Basics of IOT, Basics of AR/VR) and generic elective (Thinking and Acting like an Entrepreneur; Disciplined approach to Social Entrepreneurship) courses shall give the students flexibility and exposure to some other discipline/subject/domain which would improve candidate's employability. Tutorials and laboratories will complement lectures.

**Third year of under-graduate study (Semester V & VI):** The core course is specially designed giving adequate emphasis on the new and emerging techniques and understanding of the materials science under the changing regime and global context. The summers are about giving an exposure to practice: materials research through mini-projects, as well as industrial visits.

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.

**Precedence:**

During the design of the syllabus, we have to referred the syllabi of some National and International Universities, the names of the institutes are placed hereunder:

**National Universities**

1. IISC Bangalore- B.Sc (Research) in Materials (Consulted for the course pattern and subjects of Materials Science)

2. Calcutta University, West Bengal (Consulted for CBCS structure of B.Sc (H) course and for the subject for basic Physical Science)

3. Delhi University, Delhi (Consulted for CBCS structure of B.Sc (H) course and for the subject for basic Physical Science)

4. IIT Kharagpur, West Bengal (Consulted for the course pattern and subjects of Materials Science)

**International Universities/Institutes**

1. University of Manchester-UK (Consulted for the subjects of Materials Science))

2. MIT-USA (Consulted for the subjects of Materials Science)

3. Illinois Institute of Technology, USA (Consulted for the course pattern and subjects of Materials Science)

4. Wright State University, USA (Consulted for the course pattern and subjects of Materials Science)

**As per the rules of CBCS, a total of 120 credit points has to be earned by a student to obtain the B. Sc (General) degree in Materials Science, while further 20 credit has to be earned from online MOOCs (Massive Open Online Courses) offered by Coursera, edX, SWAYAM/nptel, nanoHub etc. (all together 140 credits) to get the B. Sc (Honours) degree in Materials Science.**

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:** 3 years

**Student Intake: 30**

**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**

**OUTLINE OF CHOICE BASED CREDIT SYSTEM**

**1. Core Course**: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

**2. Elective Course**: Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

**2.1 Discipline Specific Elective (DSE) Course**: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

**2.2 Dissertation/Project**: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

**2.3 Generic Elective (GE) Course**: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

**3. Ability Enhancement Courses (AEC):** The Ability Enhancement (AE) Courses may be of two kinds: **Ability Enhancement Compulsory Courses (AECC)** and **Skill Enhancement Courses (SEC).** "**AECC**" courses are the courses based upon the content that leads to Knowledge enhancement;

**i. Environmental Science** and **ii. English/MIL Communication**. These are mandatory for all disciplines. **SEC** courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

**3.1 Ability Enhancement Compulsory Courses (AECC):** Environmental Science, English Communication/MIL Communication.

**3.2 Skill Enhancement Courses (SEC):** These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge.

- Introducing Research Component in Under-Graduate Courses

**Project work/Dissertation** is considered as a special course involving application of knowledge in solving / analysing /exploring a real-life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

**Semester wise distribution of course**

| Subject Type | Semester I | Semester II | Semester III | Semester IV | Semester V | Semester VI |
|---|---|---|---|---|---|---|
| **CC** | C1, C2 | C3, C4 | C5, C6, C7 | C8, C9, C10 | C11, C12 | C13, C14 |
| **DSE** | | | | | DSE1, DSE2 | DSE3, DSE4 |
| **GE** | GE1 | GE2 | GE3 | GE4 | | |
| **AECC** | AECC1 | AECC2 | | | | |
| **SEC** | | | SEC1 | SEC2 | | |
| **Credit Distribution (140)** | **4(20)** | **4(20)** | **6(26)** | **5(26)** | **4(24)** | **4(24)** |

**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**

**Program Outcome**

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

| **Program Outcome** | **Mapped Courses** |
|---|---|
| **PO1.** Understand the relationship between structure, property, processing and performance of materials with basic concepts of physics and chemistry associated with Materials Science | **CC1 (BMS101), CC2 (BMS102), BMS191, BMS303, CC3 (BMS201), BMS291, CC4 (BMS202), BMS403. BMS301, BMS302, BMS401** |
| **PO2.** Work like professional scientists and engineers and develop creative and entrepreneurship skills along with computational skill | **BMS104, BMS404, BMS305, BMS405** |
| **PO3.** Develop their knowledge about the fundamentals of materials design and selection and their industrial application | **BMS402, BMS492, BMS502, BMS591, BMS602, BMS501, BMS591** |
| **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 | **BMS103, BMS192, BMS203, BMS292, BMS304, BMS392, BMS491** |
| **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 | **BMS305, BMS581, BMS681** |
| **PO6.** Know the importance of natural resources and the need for their preservation | **BMS204, BMS503, BMS603, BMS504, BMS604** |
| **PO7.** To acquire experimental skills associated to Materials Science | **BMS601, BMS691** |

**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**

**Curriculum Structure**

| **Semester-I** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Category** | **Subject Code** | **Subject Name** | **Total no of contact hours** | | | **Credits** |
| | | | | L | T | P | |
| 1 | Core Course 1 | BMS101 | Introduction to Materials | 3 | 1 | 0 | 4 |
| 2 | Laboratory I | BMS191 | Macroscopic and Microscopic Examination of Materials Lab | 0 | 0 | 4 | 2 |
| 3 | Core Course 2 | BMS102 | Classical Physics for Materials Science | 5 | 1 | 0 | 6 |
| 4 | Generic Elective 1 | BMS103 | GE 1 (Choose from Basket 1 of General Science) | 3 | 1 | 0 | 4 |
| 5 | Laboratory II | BMS192 | | 0 | 0 | 4 | 2 |
| 6 | Ability Enhancement Compulsory Course (AECC1) | BMS 104 | Communicative English | 2 | 0 | 0 | 2 |
| | | | **Total of Semester-I** | **13** | **3** | **8** | **20** |
| **Semester-II** | | | | | | | |
| **Sl. No.** | **Category** | **Subject Code** | **Subject Name** | **Total no of contact hours** | | | **Credits** |
| | | | | L | T | P | |
| 1 | Core Course 3 | BMS 201 | Materials Chemistry | 3 | 1 | 0 | 4 |
| 2 | Laboratory I | BMS 291 | Materials Synthesis Lab | 0 | 0 | 4 | 2 |
| 3 | Core Course 4 | BMS 202 | Quantum Physics for Materials Science | 5 | 1 | 0 | 6 |
| 4 | Generic Elective 2 | BMS 203 | GE 2 (Choose from Basket 2 of Mathematics) | 3 | 1 | 0 | 4 |
| 5 | Laboratory II | BMS 292 | | 0 | 0 | 4 | 2 |
| 6 | Ability Enhancement Compulsory Course (AECCII) | BMS 204 | Environment & Sustainability | 2 | 0 | 0 | 2 |
| | | | **Total of Semester-II** | **13** | **3** | **8** | **20** |

**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**

**Curriculum Structure**

| Semester-III | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Category** | **Subject Code** | **Subject Name** | **Total no of contact hours** | | | **Credits** |
| | | | | L | T | P | |
| 1 | Core Course 5 | BMS 301 | Thermodynamics of Materials | 5 | 1 | 0 | 6 |
| 2 | Core Course 6 | BMS 302 | Kinetics of Materials and Transport Phenomena | 3 | 1 | 0 | 4 |
| 3 | Laboratory I | BMS 391 | Introduction to Finite Element Analysis | 0 | 0 | 4 | 2 |
| 4 | Core Course 7 | BMS 303 | Structure of Materials | 5 | 1 | 0 | 6 |
| 5 | Generic Elective 3 | BMS 304 | GE 3 (Choose from Basket 3 of Emerging Technologies) | 4 | 0 | 0 | 4 |
| 6 | Laboratory II | BMS 392 | | 0 | 0 | 4 | 2 |
| 7 | Skill Enhancement Course I (SEC– I) | BMS 305 | SEC 1 (Choose from the corresponding table of SEC) | 2 | 0 | 0 | 2 |
| 8 | Audit Course | BMS 306 | Research Methodology | 0 | 0 | 0 | 0 |
| | | | **Total of Semester-III** | **21** | **3** | **8** | **26** |
| **Sl. No.** | **Category** | **Subject Code** | **Subject Name** | **Total no of contact hours** | | | **Credits** |
| | | | | L | T | P | |
| 1 | Core Course 8 | BMS 401 | Phase Equilibria and Phase Transformation | 3 | 1 | 0 | 4 |
| 2 | Laboratory I | BMS 491 | Intermediate Programing with Python Lab | 0 | 0 | 4 | 2 |
| 3 | Core Course 9 | BMS 402 | Materials Behavior: Mechanical, Electrical & Magnetic | 3 | 1 | 0 | 4 |
| 4 | Laboratory II | BMS 492 | Materials Behavior Lab-I | 0 | 0 | 4 | 2 |
| 5 | Core Course 10 | BMS 403 | Processing of Bulk Materials | 5 | 1 | 0 | 6 |
| 6 | Generic Elective 4 | BMS 404 | GE 4 (Choose from Basket 4 of Entrepreneurship, Innovation & Social Sciences) | 5 | 1 | 0 | 6 |
| 7 | Skill Enhancement Course II (SEC-III) | BMS 405 | SEC 2 (Choose from the corresponding table of SEC except the course chosen in SEC 1) | 2 | 0 | 0 | 2 |
| | | | **Total of Semester-IV** | **18** | **4** | **8** | **26** |

**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**

## Curriculum Structure

| Semester-V | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Category** | **Subject Code** | **Subject Name** | **Total no of contact hours** | | | **Credits** |
| | | | | L | T | P | |
| 1 | Core Course 11 | BMS 501 | Thin films and Nano Materials | 3 | 1 | 0 | 4 |
| 2 | Laboratory I | BMS 591 | Nano-Materials Lab | 0 | 0 | 4 | 2 |
| 3 | Core Course 12 | BMS 502 | Materials Behavior: Electronic and Optical | 3 | 1 | 0 | 4 |
| 4 | Laboratory II | BMS 592 | Materials Behaviour Lab-II | 0 | 0 | 4 | 2 |
| 5 | Discipline Specific Elective 1 | BMS 503 | DSE – 1 (Choose from the corresponding basket DSE-1) | 3 | 0 | 0 | 3 |
| 6 | Discipline Specific Elective (Sessional) | BMS 581 | Project Work | 0 | 0 | 6 | 3 |
| 7 | Discipline Specific Elective 2 | BMS 504 | DSE – 2 (Choose either of A/B/C/D/E/F from the corresponding table) | 5 | 1 | 0 | 6 |
| | | | **Total of Semester-V** | **14** | **3** | **14** | **24** |

| **Sl. No.** | **Category** | **Subject Code** | **Subject Name** | **Total no of contact hours** | | | **Credits** |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | Core Course 13 | BMS 601 | Materials Characterization | 3 | 1 | 0 | 4 |
| 2 | Laboratory I | BMS 691 | Materials Characterization Lab | 0 | 0 | 4 | 2 |
| 3 | Core Course 14 | BMS 602 | Design and Selection of Materials | 5 | 1 | 0 | 6 |
| 4 | Discipline Specific Elective 3 | BMS 603 | DSE – 3 (Choose from the corresponding basket except the course chosen in DSE 1) | 3 | 0 | 0 | 3 |
| 5 | Discipline Specific Elective (Sessional) | BMS 681 | Project Work | 0 | 0 | 6 | 3 |
| 6 | Discipline Specific Elective 4 | BMS 604 | DSE – 4 (Choose either of A/B/C/D/E/F except the course chosen in DSE 2 from the corresponding table) | 5 | 1 | 0 | 6 |
| | | | **Total of Semester-VI** | **16** | **3** | **10** | **24** |

**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**

**A student has to earn minimum of 140 credits in 3 years to get the B. Sc(H) degree**

**List of electives: SEC courses for SEMESTER –III (BMS 305) (Mode of Delivery: Offline)**

*Classroom Equivalent Online Courses offered for B. Sc in Materials Science*

| Sl. No. | Course Name | Course Provider | Course Duration | Credits | Name of University/Institute |
|---|---|---|---|---|---|
| A | AI For Everyone | coursera | 4 weeks | 1 | deeplearning.ai |
| B | Introduction to Artificial Intelligence (AI) | coursera | 4 weeks | 1 | IBM |
| C | IoT (Internet of Things) Wireless & Cloud Computing Emerging Technologies | coursera | 6 weeks | 2 | Yonsei University |
| D | Basics of Block Chain Technology (BCT) | edx | 6 weeks | 2 | University of California, Berkley |
| E | Interactive Computer Graphics | coursera | 7 weeks | 2 | University of Tokyo |

**List of electives: SEC courses for SEMESTER –IV (BMS 406) (Mode of Delivery: Offline)**

*Classroom Equivalent Online Courses offered for B. Sc in Materials Science*

| Sl. No. | Course Name | Course Provider | Course Duration | Credits | Name of University/Institute |
|---|---|---|---|---|---|
| A | AI For Everyone | coursera | 4 weeks | 1 | deeplearning.ai |
| B | Introduction to Artificial Intelligence (AI) | coursera | 4 weeks | 1 | IBM |
| C | IoT (Internet of Things) Wireless & Cloud Computing Emerging Technologies | coursera | 6 weeks | 2 | Yonsei University |
| D | Basics of Block Chain Technology (BCT) | edx | 6 weeks | 2 | University of California, Berkley |
| E | Interactive Computer Graphics | coursera | 7 weeks | 2 | University of Tokyo |

**List of electives: DSE 2 courses for SEMESTER –V (BMS 504) (Mode of Delivery: Offline)**

| Sl. No. | Course Name |
|---|---|
| A | Bio Materials |
| B | Energy Materials |
| C | Metallic Materials |
| D | Polymeric Materials |
| E | Ceramic Materials |
| F | Composite Materials |

**List of electives: DSE 4 courses for SEMESTER –VI (BMS 604) (Mode of Delivery: Offline)**

| Sl. No. | Course Name |
|---|---|
| A | Bio Materials |
| B | Energy Materials |
| C | Metallic Materials |
| D | Polymeric Materials |
| E | Ceramic Materials |
| F | Composite Materials |

**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**

**Basket for DSE 1 & DSE 3 (Mode of Delivery: Blended)** *This will be guided by faculty in Offline mode*

| Sl. No. | Course Name | Course Provider | Course Duration | Name of University/Institute |
|---|---|---|---|---|
| **1** | Non-conventional energy Resources | Swayam | 12 weeks | IIT Madras |
| **2** | Nanotechnology: A Maker's Course (8 wk.)<br>&<br>Materials in Oral Health (4 wk.) | coursera | 12 weeks | Duke University<br><br>Univ. of Hong Kong |
| **3** | Materials Data Sciences and Informatics (5 wk.)<br>&<br>Transmission electron microscopy for materials science (8 wk.) | coursera | 13 weeks | Georgia Tech Univ.<br>&<br>École Polytechnique Fédérale de Lausanne |
| **4** | Introduction to solar cells (5 wk.)<br>&<br>Materials in Oral Health (4 wk.) | coursera | 9 weeks | Technical Univ. of Denmark<br><br>Univ. of Hong Kong |
| **5** | Nanotechnology and Nano sensors, Part1 (5 wk.)<br>&<br>Nanotechnology & Nano sensors, Part 2 (5 wk.) | Coursera | 10 weeks | Technion – Israel Institute of Technology |
| **6** | Introduction to Thermodynamics: Transferring Energy from Here to There | coursera | 8 weeks | Univ. of Michigan |
| **7** | Medical Biomaterials | NPTEL | 8 weeks | IIT Madras |
| **8** | Waste to Energy Conversion | NPTEL | 8 weeks | IIT Roorkee |
| **9** | Fundamental concepts of semiconductors | NPTEL | 6 weeks | IIT Delhi |
| **10** | Basics of Finite Element Analysis-I | NPTEL | 8 weeks | IIT Kanpur |
| **11** | Physics of Materials | NPTEL | 8 weeks | IIT Madras |
| **12** | Optoelectronics Materials and Devices | NPTEL | 8 weeks | IIT Kanpur |
| **13** | Nanotechnology in Agriculture | NPTEL | 8 weeks | IIT Kanpur |
| **14** | Nature and Properties of Materials | NPTEL | 8 weeks | IIT Kanpur |
| **15** | Materials Science: 10 Things Every Engineer Should Know | Coursera | 5 weeks | University of California, Davis |
| **16** | Phase equilibrium thermodynamics | NPTEL | 8 weeks | IIT Kharagpur |
| **17** | Diffusion in Multicomponent Solids | NPTEL | 12 weeks | IIT Kanpur |
| **18** | Introduction to Composites | NPTEL | 12 weeks | IIT Kanpur |
| **19.** | Computational Materials Science | nanoHUB | 6 weeks | University of Illinois |
| **20.** | Introduction to Physical Chemistry | Coursera | 10 weeks | The Univ. of Manchester |
| **21.** | Mechanics of Materials I: Fundamentals of Stress & Strain and Axial Loading<br>&<br>Mechanics of Materials II: Thin-Walled Pressure Vessels and Torsion | coursera | 8 weeks | Georgia Tech Univ. |
| **22.** | Fundamentals of electronic device fabrication | NPTEL | 4 weeks | IIT Madras |

* *This basket is dynamic and courses will be updated accordingly as per its availability*

*Passed in Board of Studies held on 03-04-2023*

**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**

## Generic Elective Basket for SEMESTER I, II, III, IV

| GE Basket 1 | | GE Basket 2 | | GE Basket 3 | | GE Basket 4 | |
|---|---|---|---|---|---|---|---|
| General Science | | Mathematics | | Emerging Technologies | | Entrepreneurship, Innovation & Social Sciences | |
| 1 | Statistical Methods for Materials Science & Introduction to Programming using C and MATLAB (Lab) | 1 | Mathematics & Data Analysis, Visualization and Interpretation using MATLAB (Lab) | 1 | Introduction to Programming using Python & Python Programming Lab (Lab) | 1 | Innovation & Entrepreneurship - From Design Thinking to Funding Coursera. EIT Digital |
| 2 | How Things Work: An Introduction to Physics Coursera, Univ. of Virginia | 2 | Mathematics for Computing | 2 | Introduction to Data, Signal, and Image Analysis with MATLAB Coursera, Vanderbilt Univ. 5wk | 2 | Introduction to Public Speaking Coursera, University of Washington |
| 3 | Advanced Chemistry Coursera, Univ. of Kentucky | 3 | Simulation and Modelling Natural Processes | 3 | Introduction to Programming with MATLAB Vanderbilt Univ. | 3 | Becoming a changemaker: Introduction to Social Innovation; Coursera, Univ. of Cape Town |
| 4 | Environmental Law and Policy | 4 | Operations Research | 4 | Digital Marketing | 4 | Write Professional Emails in English Coursera, Georgia Institute of Technology |
| 5 | Intelligence of Biological Systems | 5 | Data Analytics | 5 | Introduction to AR/VR | 5 | Design Thinking for Innovation |

## Virtual Lab Mapping

| Sl. No. | Lab Code | Virtual Lab Link |
|---|---|---|
| 1. | **BMS 191: Macroscopic and Microscopic Examination of Materials** | https://phet.colorado.edu/ |
| 2. | **BMS 291: Materials Synthesis Lab** | https://www.vlab.co.in/broad-area-chemical-sciences |
| 3. | **BMS 492: Materials Behavior Lab-I** | http://mrmsmtbs-iitk.vlabs.ac.in/home%20page.html |
| 4. | **BMS 591: Nano-Materials Lab** | http://mrmsmtbs-iitk.vlabs.ac.in/home%20page.html |
| 5. | **BMS 592: Materials Behavior Lab-II** | http://sm-nitk.vlabs.ac.in/<br>http://bsa-iiith.vlabs.ac.in/ |
| 6. | **BMS 691: Materials Characterization Lab** | https://www.vlab.co.in/broad-area-chemical-sciences |

| | | |
|---|---|---|
| | | https://www.vlab.co.in/broad-area-chemical-sciences |

**Marking Scheme followed for evaluation of student's Continuous Assessment**

**BASIS FOR CONTINUOUS ASSESSMENT (CA):** Continuous assessment marks in each theory course shall be based on any of the following evaluation procedure to be adopted by the faculty concerned with the subject like tests, assignments, power point presentation and viva voice. During each semester four CA has to be conducted CA-1, CA-2, CA-3, CA-4 and best of four will be counted for final evaluation.

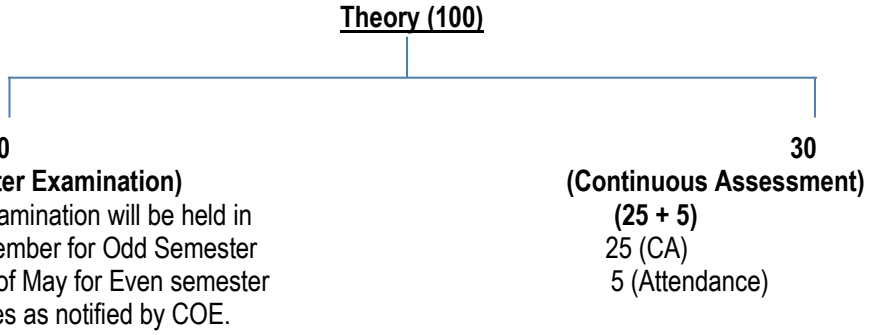
Internal assessment marks in each Laboratory course are assessed by the faculty members of the department based on the regular performance in the laboratory, the viva conducted on each experiment, the internal test and the laboratory records submitted by the student. During each semester two internal practical test has to be conducted and termed as PCA-1 & PCA-2 and best of two will be counted for final evaluation

**PROJECT REPORT:** A project carried out by the student in V and VI semesters will be evaluated in each semester as stipulated in the regulations. The internal assessment for the project is evaluated by the faculty members of the department. And, final semester project evaluation will be done by open viva voice. For evaluation purpose of the same one external examiner has to be present.

**Theory = 100;** **Laboratory = 100**

**Distribution of Marks for Theory paper**

Each Theory paper marks (100) is divided as = 70 (End Semester Examination) + 30 (Continuous Assessment)



**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**

## Distribution of Marks for Laboratory

Each Laboratory marks (100) is divided as = 60 (End Semester Examination) + 40 (Internal Assessment)

**Laboratory (100)**

**60 marks**
**(End Semester Examination)**
**(External)**

2 Experiments to be performed
or
maintenance
2 Computer programs to be written
**30 marks**
**Duration of Exam: 3 hours**
**10 marks:** Viva (to judge the concept of the student)
**15 marks:** Lab copy
**5 marks**: Attendance

**40 marks**
**(Internal Assessment)**
**25 marks**: For experiments performed (in whole Semester)
**5 marks**: Viva Voice
**5 marks**: Lab copy

**5 marks**: Attendance

**Distribution of marks for attendance**

| Sl. No. | Attendance Range | Marks to be allotted |
|---|---|---|
| 1 | 75% > | 1 |
| 2 | 80% > | 2 |
| 3 | 85% > | 3 |
| 4 | 90% | 4 |
| 5 | 90% > | 5 |

**Grading System**

| Sl. No. | Range of Marks | Letter Grade | Marks |
|---|---|---|---|
| 1 | 40-50 | D(Pass) | 5 |
| 2 | 50-60 | C (Average) | 6 |
| 3 | 60-70 | B (Good) | 7 |
| 4 | 70-80 | A (Very good) | 8 |
| 5 | 80-90 | E (Excellent) | 9 |
| 6 | 90-100 | O (Outstanding) | 10 |
| 7 | Less than 40 | Fail | |
| 8 | -- | Absent | 0 |

# PART – B

# DETAILED SYLLABUS

**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**
**SEMESTER I**

## (BMS101) Core Course (CC 1): Introduction to Materials L-T-P: 3-1-0 (Credit - 4)

**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 12L**
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)

**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**

**(BMS102) Core Course (CC 2): Classical Physics for Materials Science L-T-P: 5-1-0 (Credit - 6)**

**Course Objectives:**

The course will give deeper understanding of fundamental concepts in mechanics such as force, energy, momentum, SHM etc. needed for further studies in Materials Science. It will introduce basic concept of physics responsible for different physical properties of materials.

**Course Content**

**1. Fundamentals of Dynamics:** Review of Newton's Laws: Mechanistic view of the Universe. Concepts of Inertial frames, force and mass. Solution of the equations of motion (E.O.M.) in simple force held in one, two- and three-dimensions using Cartesian, cylindrical polar and spherical polar coordinate systems **Offline 20L**

**2. Dynamics of systems of particles**: Difficulty of solving the E.O.M. for systems of particles. Newton's third Law. External and Internal forces. Momentum and Angular Momentum of a system. Torque acting on a system. Conservation of Linear and Angular Momentum. Centre of mass and its properties. Two-body problem. Variable-mass system: motion of rocket. **Online 15L**

**3. Work and Energy:** Work - Kinetic Energy Theorem. Conservative Forces: Force as the gradient of a scalar field - concept of Potential Energy. Other equivalent definitions of a Conservative Force. Conservation of Energy. Qualitative study of one-dimensional motion from potential energy curves. Stable and Unstable equilibrium. Energy of a system of particles.

**Online 15L**

**4. Oscillations:** SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values

**Offline 12L**

**5. Superposition of Harmonic Oscillations:** Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences

**Online 10L**

**Suggested readings:**

1. An Introduction to Mechanics: Daniel Kleppner and Robert Kolenkow, 2nd Edition 2014, Cambridge University Press
2. Introduction to Classical Mechanics: With Problems and Solutions: David Morin, 2008, Cambridge University Press
3. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson
4. Fundamentals of Physics: Halliday, Resnick and Walker, 8th Edition 2008, Wiley
5. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

| Sl. No | **Course Outcome:** On successful completion of this course, student should be able to |
|---|---|
| 1 | Solve the Newton equations for simple configurations using various methods & able to solve advanced problems involving the dynamic motion |
| 2 | Represent the equations of harmonic motion of oscillation with same phase difference or equal frequencies |
| 3 | Use conservation of energy and linear and angular momentum to solve dynamics problems |

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

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**Department of Materials Science and Technology**

**BACHELOR OF SCIENCE IN MATERIALS SCIENCE**

**CO-PO Mapping**

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

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

**Maulana Abul Kalam Azad University of Technology, West Bengal**
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**Department of Materials Science and Technology**
**BACHELOR OF SCIENCE IN MATERIALS SCIENCE**

## (BMS103) Generic Elective (GE 1): Statistical Methods for Materials Science

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

**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

## (BMS 104) Ability Enhancement Compulsory Course (AECC I): Communicative English

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

**Course Objectives:** The course will enable students to talk in English so that he/she could express their views on any topic without any difficulty in speech and enable them to communicate effectively and appropriately in real life situation. The course will enable learner to develop and demonstrate the speaking skills for group discussions.

**Course Content**

| Module Number | Content |
|---|---|
| Module 1 | Small Talk & Conversational Vocabulary; Express Yourself: Pronunciation; Elevator Speech |
| Module 2 | Video Conferencing: Face to Face but Online; Group Discussion Language; Video Conference Role Play |
| Module 3 | Telephone Language; Understand and Be Understood on the Phone; Phone Role Play |
| Module 4 | Get Ready for the Interview; Improve Your Pronunciation: -ed & -s endings; Interview Role Play |

**Online course:**
Speak English Professionally: In Person, Online & On the Phone, coursera, 5 weeks, 2 credit
https://www.coursera.org/learn/speak-english-professionally/home/week/5

**Suggested readings:**

1. S R Inthira&amp, V Saraswathi, Enrich your English a) Communication skills b) Academic skills, CIEFL &amp, OUP
2. R.C. Sharma and K.Mohan Business Correspondence and Report Writing Tata McGraw Hill , New Delhi , 1994
3. Maxwell Nurnberg and Rosenblum Morris, All About Words- A Text Book for English for Engineers &amp, Technologists General Book Depot, New Delhi, 1995

| Sl. No | **Course Outcome:** On successful completion of this course, student should be able to |
|---|---|
| **1** | Prepare themselves better for an interview in English. The three lessons will focus on improving your body language, pronunciation for -ed and -s ending words, |
| **2** | Have the chance to put all your newly gained language skills together into a presentation. This module will teach the presentation skills |
| **3** | Speak English and Improve your pronunciation and fluency. Communicate in Person: The Power of Face to Face Connections |

**CO-PO Mapping**

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

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

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**BACHELOR OF SCIENCE IN MATERIALS SCIENCE**

## SEMESTER –II

**(BMS201) Core Course (CC 3): Materials Chemistry** **L-T-P: 3-1-0 (Credit - 4)**

**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) Core Course (CC 4): Quantum Physics for Materials Science**

**L-T-P:5-1-0 (Credit - 6)**

**Course Objectives:**

This course will introduce basic concepts of quantum physics and correlation to materials science.

**Course Content**

**1. Introduction to Quantum mechanics**: Plank's-Blackbody radiation/UV catastrophe, Einstein, de-Broglie, Heisenberg Uncertainty principle. **Online 20L**

**2. Schrodinger Equation**: Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in one dimension. Fourier transforms and momentum space wavefunction. Position-Momentum uncertainty.

**Offline 15L**

**3. General discussion of bound states in an arbitrary potential**: Continuity of wave function, boundary condition and emergence of discrete energy levels. Application to one-dimensional problem square well potential.

**Offline 20L**

**4. Quantum mechanics of simple harmonic oscillator**: Setting up the eigenvalue equation for the Hamiltonian. Energy levels and energy Eigen functions in terms of Hermite polynomials (Solution to Hermite differential equation may be assumed). Ground state, zero-point energy & uncertainty principle, Quantum mechanics in three-dimension

**Offline/Online 20 L**

**LEARNING RESOURCES:**

1. Introduction to Quantum Mechanics, David J. Griffiths, 2nd Edition 2005, Pearson
2. Quantum Physics: Stephen Gasiorowicz, 3rd Edition 2008, Wiley
3. Practical Quantum Mechanics, Flügge, Siegfried, Springer
4. Quantum Mechanics: An Introduction: Walter Greiner, 2001, Springer
4. The Principles of Quantum Mechanics: P. A. M. Dirac, 4th Edition, 1987, Oxford Science Publication
5. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.

## 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 environment and ecosystem and its influence on biome |
| CO-2 | Develop and knowledge and application skill to analyse the natural resources, their conservation and capability to manage the resources |
| CO-3 | Able to protect the nature and its resources against pollution, conservation and cater the social issues out of it. |

## CO-PO Mapping:

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

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CO3** | 3 | 3 | 3 | 3 | 3 | 1 | - |

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

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

**BACHELOR OF SCIENCE IN MATERIALS SCIENCE**

## (BMS203) Generic Elective (GE 2): Mathematics

**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**

**BACHELOR OF SCIENCE IN MATERIALS SCIENCE**

**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:**

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

**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

**(BMS204) Ability Enhancement Compulsory Course (AECC II): Environment & Sustainability**

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

**Course Objectives:**

This course will students to nurture the environment and to take care of it. It will help students to know the importance of natural resources and the need for the preservation.

**Course Content**

**1. Introduction to environmental studies & ecosystems**: Multidisciplinary nature of environmental studies: Scope and importance; what is an ecosystem? The structure and function of ecosystem, Energy flow in an ecosystem, food chains, food webs and ecological succession, forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystems

**Offline/ Online 10L**

**2. Natural resources & its management and conservation**: Land resources and land use change: Land degradation, soil erosion and desertification; Deforestation: Causes and impacts, forests, biodiversity and tribal populations; Water: Use and over-exploitation of surface and ground water. Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources and growing energy needs.

**Offline 6L**

**3. Environmental pollution & management:** Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution, Solid waste management: Control measures of urban and industrial waste. Climate change, global warming, Environment Laws: Environment Protection Act, Air (Prevention & Control of Pollution) Act, Water (Prevention and control of pollution) Act, Wildlife Protection Act, Forest Conservation Act; International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD) **Online 6L**

**4. Environment & social issues:** Human population growth: Impacts on environment, human health and welfare; Resettlement and rehabilitation of project affected persons; case studies; Disaster management: floods, earthquake, cyclones and landslides; Environmental ethics: environmental conservation; environmental communication and public awareness.

**Offline 6L**

**LEARNING RESOURCES:**

1. Carson, R. 2002. Silent Spring. Houghton Mifflin Harcourt.
2. Gadgil, M., & Guha, R. 1993. This Fissured Land: An Ecological History of India. Univ. of California Press.
3. Gleeson, B. and Low, N . (eds.) 1999. Global Ethics and Environment, London, Routledge.
4. Gleick, P. H. 1993. Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
5. Groom, Martha J., Gary K. Meffe, and Carl Ronald Carroll. Principles of Conservation Biology. Sunderland: Sinauer Associates, 2006.

**Online Course**

Ecology: Ecosystem Dynamics and Conservation, American Museum of Natural History, coursera 5 weeks, 2 credit

**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 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 | - |
| **CO2** | 2 | - | 1 | - | 2 | 3 | - |
| **CO3** | 2 | 2 | 1 | - | 3 | 3 | 1 |

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

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

## (BMS 301) Core Course (CC 5): Thermodynamics of Materials

**L-T-P: 5-1-0 (Credit - 6)**

**Course Objectives:**

This course will introduce basic concepts of materials thermodynamics and help to understand how the entropy of the material changes on the application of heat.

**Course Content**

1. **Zeroth and First Law of Thermodynamics**: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature. Concept of Work & Heat, State Functions, Internal Energy and First Law of Thermodynamics. Its differential form, First Law & various processes. Applications of First Law: General Relation between $C_p$ and $C_V$, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient.

**Offline 20L**

**2. Second Law of Thermodynamics**: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence.

**Online 16L**

**3. Carnot's Theorem. Applications of Second Law of Thermodynamics**: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

**Offline/Online 20L**

**4. Entropy**: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature-Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero

**Offline 20L**

**LEARNING RESOURCES:**

1. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
2. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
3. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
4. Introduction to Thermodynamics: Transferring Energy from Here to There, coursera, 8 weeks, 2 credit, Univ. of Michigan

| Sl. No | **Course Outcome:** On successful completion of this course, student should be able to |
|---|---|
| 1 | Understand the concepts of laws of thermodynamics with its applications in materials science. |
| 2 | Apply the basic concepts of heat and mass transfer, the equations governing them and its application in thermodynamics |

**CO-PO Mapping**

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

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

## (BMS 302) Core Course (CC 6): Kinetics and Transport Phenomena of Materials

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

**Course Objectives:**

This course will introduce basic concepts of Thermal and Transport Properties in materials. It will make understand the learners how energy transport within the material.

**Course Content**

Thermal and Transport Properties of Materials: The thermo-physical and transport properties of solids and fluids, i.e. heat capacity, expansion, viscosity, conduction, convection, and radiation are discussed, along with thermal analysis instrumentation.

**1. Introduction to Transport Phenomena:** Basics of momentum transport: Euler/Lagrangian viewpoint, laminar and turbulent flows, boundary layers, stress tensor. **Offline 10L**

**2. Shell momentum balances:** Equations of change, dimensional analysis, applications to isothermal flow of Newtonian & non-Newtonian fluids. **Online 10L**

**3. Basics of energy transport:** Conductive, convective radiation, dissipation of heat fluxes, steady state, non-steady state heat transfer. Equations of change for non-isothermal systems, dimensional analysis, and applications to steady-state conduction & convection.

**Offline 10L**

**4. Basics of mass transport:** Mechanisms, and mass & molar fluxes, Derivation of equation of continuity for a binary mixture and its application to convection-diffusion problems. Heat transfer.

**Online 10L**

**5. Diffusion**: Fick's First and Second Laws. Atomistic mechanisms of diffusion: interstitial and substitutional diffusion. Diffusion paths: lattice, grain boundary, Steady vs. unsteady state diffusion.

**Offline 10L**

**LEARNING RESOURCES:**

1. Transport Phenomena: R. B. Bird, W. E. Stewart, and E. S. Lightfoot, 2nd Edition 2002, Wiley
2. Analysis of Transport Phenomena: W. M. Deen, 1998, Oxford University Press.
3. Fundamentals of Momentum, Heat, and Mass Transfer: J. Welty, C. E. Wicks, R. E. Wilson, and G. L. Rorrer, 5th Edition 2007, Wiley.
4. Introduction to Transport Phenomena: W. J. Thompson, 2000, Prentice Hall.
5. Unit Operations of Chemical Engineering: Warren McCabe, Julian Smith and Peter Harriott, 7th Edition 2017, McGraw-Hill

| Sl. No | **Course Outcome:** On successful completion of this course, student should be able to |
|---|---|
| 1 | Understand the concepts of transport phenomena of heat, mass in materials |
| 2 | Analyse and apply the concept diffusion in improving the materials properties |

**CO-PO Mapping**

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

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

## (BMS 303) Core Course (CC 7): Structure of Materials

**L-T-P: 5-1-0 (Credit - 6)**

**Course Objectives:**

This unit introduces the concept of a microstructure in materials science and how the property changes depending on the microstructure. The importance of microstructure in determining material properties is introduced.

**Course Content**

**1. Crystal Structure**: Crystal systems. Bravais lattices. Symmetry. Miller indices of directions and planes. Bragg's Law. Close-Packed structures: CCP, HCP. Voids in close-packed structures. Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis Central and Non-Central Elements. Reciprocal Lattice, Atomic and Geometrical Factor. Materials of Importance—Tin (Its Allotropic Transformation) Crystal Systems, crystallographic points, directions, and planes, point coordinates, crystallographic directions, crystallographic planes, linear and planar densities **Offline 20L**

**2. Crystalline Materials:** Single Crystals, Polycrystalline Materials, Anisotropy, X-Ray Diffraction: Determination of Crystal Structures, Non-crystalline Solids

**Online 16L**

**3. Metallic Materials:** Metals and alloys, Ferrous alloys, Steel, the Phase rule and phase diagrams of Fe-C system and common non-ferrous alloys, Eutectic, Eutectoid, Peritectic diagrams, TTT diagram, Liver rule.

**Offline 12L**

**4. Polymeric Materials:** Classification of Polymers, Structure of Long Chain Polymers, Crystallinity of Long Chain Polymers. polymerizations processes, step polymerizations and addition polymerization, degradation and stabilization of polymers, conducting polymers, common polymers, their synthesis, properties and applications.

**Offline/Online 10L**

**5. Ceramic materials:** Crystal Structures, Silicate Ceramics, Carbon, Imperfections in Ceramics, Ceramic Phase Diagrams

**Online 15L**

**LEARNING RESOURCES:**

1. Materials Science and Engineering – William D. Callister, Jr
2. Materials Science and Engineering, A First Course – V. Raghavan
3. Mechanical Metallurgy, George E Dieter. Mcgraw Hill, London.
4. Introduction to Materials Science and Engineering-Web course---http://nptel.iitm.ac.in
5. http://neon.mems.cmu.edu/cramb/Processing/history.html

| Sl. No | **Course Outcome:** On successful completion of this course, student should be able to |
|---|---|
| 1 | Understand the concept of microstructure of different class of materials |
| 2 | Analyse how microstructure dictates the materials properties and finally the performance |

**CO-PO Mapping**

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

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

**(BMS 304) Generic Elective (GE 3): Choose from Basket 3 of Emerging Technologies (Credit: 6)**

| GE Basket 1 | | GE Basket 2 | | GE Basket 3 | | GE Basket 4 | |
|---|---|---|---|---|---|---|---|
| General Science | | Mathematics | | Emerging Technologies | | Entrepreneurship, Innovation & Social Sciences | |
| 1 | Statistical Methods for Materials Science & Introduction to Programming using C and MATLAB (Lab) | 1 | Mathematics & Data Analysis, Visualization and Interpretation using MATLAB (Lab) | 1 | Introduction to Programming using Python & Python Programming Lab (Lab) | 1 | Innovation & Entrepreneurship - From Design Thinking to Funding Coursera. EIT Digital 6wk 2 cr |
| 2 | How Things Work: An Introduction to Physics Coursera, Univ. of Virginia, 8 wks, 2 cr | 2 | Mathematics for Computing | 2 | Introduction to Data, Signal, and Image Analysis with MATLAB Coursera, Vanderbilt Univ. 5wk 2 cr | 2 | Introduction to Public Speaking Coursera, University of Washington 5wk 2 cr |
| 3 | Advanced Chemistry Coursera, Univ. of Kentucky, 5 wk, 2 cr | 3 | Simulation and Modelling Natural Processes | 3 | Introduction to Programming with MATLAB Vanderbilt Univ. 9 wk, 3 cr | 3 | Becoming a changemaker: Introduction to Social Innovation; Coursera, Univ. of Cape Town, 6wk 2 cr |
| 4 | Environmental Law and Policy | 4 | Operations Research | 4 | Digital Marketing | 4 | Write Professional Emails in English Coursera, Georgia Institute of Technology (5 wk. 2 credit) |
| 5 | Intelligence of Biological Systems | 5 | Data Analytics | 5 | Introduction to AR/VR | 5 | Design Thinking for Innovation |

## Laboratory I: Introduction to Programming using Python (BMS 391)

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

1. Implementation of array operations.
2. Stacks and Queues: adding, deleting elements.
3. Circular Queue: Adding & deleting elements
4. Merging Problem: Evaluation of expressions operations on Multiple stacks & queues
5. Implementation of linked lists: inserting, deleting, inverting a linked list.

**Laboratory II: Introduction to Finite Element Analysis (BMS 392) L-T-P: 0-0-4 (Credit - 2)**

1. Introduction to Finite Element Method & Concepts. Basic Element Shapes. Node Numbering Scheme. Mesh Generation.

2. Mathematical concepts of finite element. FEM in one dimension

3. Introduction to Basic Equations of Solid Mechanics

4. Application to Solid Mechanics Problems

5. Applications: Stiffness of beam and trusses

6. Introduction of Basic Equations of Heat Transfer

7. Application to heat flow. One-Dimensional Heat Transfer

8. Application to viscous fluid mechanics.

9. Writing program in MATLAB/ANSYS/ABAQUS for Finite Element Analysis in Solid Mechanics like Bending of beams, analysis of truss and frame.

10. Writing program in MATLAB/ANSYS/ABAQUS for Finite Element Analysis in Heat Transfer and Fluid Mechanics

**(BMS 305) Skill Enhancement Course (SEC I) (Choose any one of BMS 305 A/B/C/D/E)**

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

| Sl. No. | Course Name | Course Provider | Course Duration | Credits | Name of University/Institute |
|---|---|---|---|---|---|
| **A** | AI For Everyone | coursera | 4 weeks | 1 | deeplearning.ai |
| **B** | Introduction to Artificial Intelligence (AI) | coursera | 4 weeks | 1 | IBM |
| **C** | IoT (Internet of Things) Wireless & Cloud Computing Emerging Technologies | coursera | 6 weeks | 2 | Yonsei University |
| **D** | Basics of Block Chain Technology (BCT) | edx | 6 weeks | 2 | University of California, Berkley |
| **E** | Interactive Computer Graphics | coursera | 7 weeks | 2 | University of Tokyo |

**BMS 305 A:** https://www.coursera.org/learn/ai-for-everyone/home/welcome

**BMS 305 B:** https://www.coursera.org/learn/introduction-to-ai/home/welcome

**BMS 305 C:** https://www.coursera.org/learn/iot-wireless-cloud-computing/home/welcome

**BMS 305 D:** https://www.edx.org/course/blockchain-advancing-decentralized-technology

**BMS 305 E:** https://www.coursera.org/learn/interactive-computer-graphics/home/welcome

## (BMS 401) Core Course (CC 8): Phase Equilibria and Phase Transformation

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

**Course Objectives:**

It will help to understand the importance and significance of phase equilibrium and phase change from one state to another upon change in energy. The course will help to understand how the with the thermodynamically changes within the material phase changes.

**Course Content**

1. Phases: Phase transitions, PVT behavior; description of materials – Ideal gas description, van der Waals and cubic equation of state (EOS), Virial EOS, Reduced conditions & corresponding states theories, correlations in description of material properties and behavior

   **Offline 10L**

2. Solution Thermodynamics: Fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties, thermodynamic properties of typical solutions and relationship to molecular interactions

   **Online 10L**

3. Liquid phase properties from vapor – liquid equilibrium (VLE): Gibbs energy, heat effects and property change on mixing Liquid phase properties from VLE, Gibbs energy, heat effects and property change on mixing.

   **Offline 10L**

4. VLE at low to moderate pressures: Equilibrium, phase rule & Duhem's theorem, graphical understanding of phase behavior of mixtures, activity coefficient and its use in VLE analysis, Raoult's and Henry's Law approximations, Flash calculations, Bubble and Dew point calculations, Properties of fluids from equations of state

   **Offline/Online 10L**

5. Solid State Phase Equilibrium, Phase transformations & multiphase equilibrium. Solubility Limit. One-Component (or Unary) Phase Diagrams. Binary phase diagrams. The Gibbs Phase Rule. Binary Eutectic Systems. Development of Microstructure in Eutectic Alloys. Materials of Importance—Lead-Free Solders. Ceramic and Ternary Phase Diagrams **Online 10L**

**LEARNING RESOURCES:**

1. Introduction to Chemical Engineering Thermodynamics: J. M. Smith, H. C. van Ness and M. M. Abbott, 7th Edition, McGraw – Hill

2. Fundamentals of Thermodynamics: Claus Borgnakke and Richard E. Sonntag, 2009, Wiley

3. Chemical, Biochemical and Engineering Thermodynamics: Stanley I. Sandler, 5th Edition 2017, Wiley

**Course Outcomes (COs):**

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

| CO No. | Course outcomes |
|---|---|
| CO-1 | Understand the concepts of phase, degree of freedom, component, constraints and PVT behaviour |
| CO-2 | Analyse the liquid phase properties, correlation of thermodynamic parameter with VLE equation and property alteration upon mixing |
| CO-3 | Analyse and apply the phase diagram like one, two and ternary diagrams and its application to ceramic materials |

**CO-PO Mapping:**

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

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

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

**(BMS 402) Core Course (CC 9): Materials Behavior: Mechanical, Electrical & Magnetic**

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

## COURSE OBJECTIVE

The course will give a a fundamental understanding of stress-strain curves and it will help to relate the macroscopic mechanical behavior of materials with the microscopic defects present in them. It will help to classify different types of magnetic materials and help to understand how the electrical property changes on application of temperature or defects.

**Course Content**

1. **Mechanical Behavior**: States of stress and strain Transformation of stresses in 2-d; Mohr's circle for strain Elasticity: origins, isotropic materials, anisotropic material Stress-strain curves; plasticity; empirical relations for stress and strain, criteria for necking, Yield Criteria, Plasticity and the theoretical strength of materials.

   **Offline 15L**

2. **Deformations**: Defects in crystalline solids. Slip by dislocation motion and dislocation theory, Implications of dislocation motion and dislocation multiplication, Slip in crystalline solids, Deformation twinning and kink bands, Elastic properties of dislocations, Dislocations in common crystal structures. Dislocation mobility, stress-strain behavior, and yield point phenomena, Obstacle-based strengthening; introduction to strengthening mechanisms. Work/strain hardening, Grain size hardening, Solid solution hardening and strain aging, Precipitation hardening, Strain gradient hardening and deformation of multiphase aggregates.

   **Online/ Offline 10L**

3. **Electrical properties:** Ohm's law, Electrical conductivity. Energy band structures in solids. Conduction in terms of band and atomic bonding models. Electrical resistivity of metals. Electrical characteristics of alloys. Semi conductivity. Temperature dependence of carrier concentration, dielectric behavior, capacitance

   **Offline 15L**

4. **Introduction to Magnetism**: Classification, Dia, Para, Ferro, Antiferro and Ferrimagnetism, Hysteresis in magnetic materials, Langevin and Weiss theories. Quantum theory of diamagnetism, Para magnetism, Hund rule, Crystal field splitting, Exchange interaction, Magnetic anisotropy, Magnetic domains, Magnetic order

   **Online 10L**

## LEARNING RESOURCES:

1. A.S.M. Handbook-Vol. 14, Forming and Forging, ASM International.

2. Metal Forming Handbook, Schuler, Springer Berlin Heidelberg.

3. Metal Forming Science and Practice, Ed. John G Lenard, Elsevier Science Ltd., U.K.

4. Electronic, Magnetic, and Optical Materials (Advanced Materials and Technologies)-Pradeep Fulay & Jung-Kun Lee, CRC Press, Taylor & Francis Group.

**5. Hyperlink:**

https://www.edx.org/course/mechanical-behavior-materials-part-1-mitx-3-032-1x-1

https://www.edx.org/course/mechanical-behavior-materials-part-1-mitx-3-032-1x-2

**Course Outcomes (COs):**

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

| CO No. | Course outcomes |
|---|---|
| CO-1 | Understand the fundamental of material behaviour |
| CO-2 | Understand the basics of mechanical, electrical and magnetic properties and behaviour of materials |
| CO-3 | Application of material properties like mechanical, magnetic and electrical towards development of dielectric, crystal field ordering and exchange interaction functions. |

**CO-PO Mapping:**

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

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

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

## (BMS 403) Core Course (CC 10): Processing of Bulk Materials

**L-T-P: 5-1-0 (Credit - 6)**

### COURSE OBJECTIVE

Primarily, provide the student with an understanding and awareness of the common processing technologies for metallic, ceramic, polymeric, and composite materials.

**Course Content**

1. **Metallic Alloys:** Ferrous Alloys. Nonferrous Alloys. Casting. Thermal processing of metals. Annealing. Heat treatment of steels. Precipitation Hardening **Offline 25L**
2. **Ceramics:** Types of ceramics, Fabrication and Processing of Glasses and Glass–Ceramics. Fabrication and Processing of Clay Products. Powder Pressing. Tape Casting, applications of ceramics **Online 15L**
3. **Polymers:** Introduction, Polymerization, Types of polymers, Polymer Additives, Forming Techniques for Plastics, Fabrication of Elastomers, Fabrication of Fibers and Films, Advantage and applications of polymers **Offline 15L**
4. **Composites:** Different type of composites, Necessity and advantage of composites, Different ways of forming composites, Particle-reinforced composites. Large-particle composites. Dispersion-strengthened composites. Fiber-reinforced composites **Online 20 L**

### LEARNING RESOURCES:

1. W. Kurz and D.J. Fisher, Fundamentals of Solidification, CRC Press, 1998.
2. G.E. Dieter, Mechanical Metallurgy, McGraw Hill, Inc., London, UK, 1992.
3. A. Upadhyaya, G.S. Upadhyaya, Powder Metallurgy: Science Technology and Materials, 2011
4. Thin Film Deposition – Principles and Practice by Donald L. Smith

### Course Outcomes (COs):

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

| CO No. | Course outcomes |
|---|---|
| CO-1 | Understand the basics on processing of materials like ceramic, polymer, metallic, composite etc |
| CO-2 | Disseminate the knowledge of classification of materials, processing routes, fabrication technics and sintering processes |
| CO-3 | Analyse the outcome of material processing to synthesize new materials along with their application |

**CO-PO Mapping:**

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

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

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

**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**

**(BMS 404) Generic Elective (GE 4): Choose from Basket 4 of Entrepreneurship, Innovation & Social Sciences**

**L-T-P: 5-1-0 (Credit - 6)**

| GE Basket 1 | | GE Basket 2 | | GE Basket 3 | | GE Basket 4 | |
|---|---|---|---|---|---|---|---|
| **General Science** | | **Mathematics** | | **Emerging Technologies** | | **Entrepreneurship, Innovation & Social Sciences** | |
| 1 | Statistical Methods for Materials Science<br>&<br>Introduction to Programming using C and MATLAB (Lab) | 1 | Mathematics<br>&<br>Data Analysis, Visualization and Interpretation using MATLAB (Lab) | 1 | Introduction to Programming using Python<br>&<br>Python Programming Lab (Lab) | 1 | Innovation & Entrepreneurship - From Design Thinking to Funding<br>Coursera. EIT Digital<br>6wk 2 cr |
| 2 | How Things Work: An Introduction to Physics<br>Coursera, Univ. of Virginia, 8 wks, 2 cr | 2 | Mathematics for Computing | 2 | Introduction to Data, Signal, and Image Analysis with MATLAB<br>Coursera, Vanderbilt Univ.<br>5wk 2 cr | 2 | Introduction to Public Speaking<br>Coursera, University of Washington 5wk 2 cr |
| 3 | Advanced Chemistry<br>Coursera, Univ. of Kentucky,<br>5 wk, 2 cr | 3 | Simulation and Modelling Natural Processes | 3 | Introduction to Programming with MATLAB<br>Vanderbilt Univ. 9 wk, 3 cr | 3 | Becoming a changemaker: Introduction to Social Innovation; Coursera, Univ. of Cape Town, 6wk 2 cr |
| 4 | Environmental Law and Policy | 4 | Operations Research | 4 | Digital Marketing | 4 | Write Professional Emails in English<br>Coursera, Georgia Institute of Technology<br>(5 wk. 2 credit) |
| 5 | Intelligence of Biological Systems | 5 | Data Analytics | 5 | Introduction to AR/VR | 5 | Design Thinking for Innovation |

**Laboratory I: Intermediate Programming with Python (BMS 491)**

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

1. Operations, Working, Functions and Methods Dictionaries Introduction. Accessing values in dictionaries. Working with dictionaries, Properties Functions Defining a function, Calling a function, Types of functions, Function Arguments, Anonymous functions.

2. Global and local variables Modules Importing module, Math module, Random module, Packages, Composition, Input-Output Printing on screen. Reading data from keyboard, Opening and closing file, Reading and writing files, Functions Exception, Handling Exception, Exception Handling, Except clause

3. Searching and Sorting Linear Search, Binary Search, Comparison of Linear and Binary Search, Selection Sort, Insertion Sort, Merge Sort, Quick sort, Shell Sort, Comparison of Sorting Techniques

**4. List of practical:**

1. Implementation of stacks & queues using linked lists
2. Polynomial addition, Polynomial multiplication
3. Sparse Matrices: Multiplication, addition.
4. Recursive and Non-Recursive traversal of Trees Threaded binary tree traversal. AVL tree implementation Application of Trees.
5. Application of sorting and searching algorithms Hash tables implementation: searching, inserting and deleting, searching & sorting techniques.
6. To plot one component and binary component phase diagram
7. To able to cluster materials depending on melting temperature and searching a specific material from the cluster to prepare a composite

**Laboratory II: Materials Behavior Lab (BMS 492)** **L-T-P: 0-0-4 (Credit - 2)**

1. To study the mechanical behavior of materials
2. To study the stress-strain curve of metallic materials, polymers, composites
3. To study the Electrolytic conduction of ionic crystals
4. Electrical transport properties of thin film
5. To study the electrical properties of metallic and composite materials
7. To study the hall effect of a given semiconductor materials
8. To determine the Hysteresis loop of a ferromagnetic materials

**(BMS 405) Skill Enhancement Course (SEC II) (Choose either of BMS 405 A/B/C/D/E except the course chosen in SEC-I)** **L-T-P: 2-1-0 (Credit - 2)**

| Sl. No. | Course Name | Course Provider | Course Duration | Credits | Name of University/Institute |
|---|---|---|---|---|---|
| **A** | AI For Everyone | coursera | 4 weeks | 1 | deeplearning.ai |
| **B** | Introduction to Artificial Intelligence (AI) | coursera | 4 weeks | 1 | IBM |
| **C** | IoT (Internet of Things) Wireless & Cloud Computing Emerging Technologies | coursera | 6 weeks | 2 | Yonsei University |
| **D** | Basics of Block Chain Technology (BCT) | edx | 6 weeks | 2 | University of California, Berkley |
| **E** | Interactive Computer Graphics | coursera | 7 weeks | 2 | University of Tokyo |

*Classroom Equivalent Online Courses offered for B. Sc in Materials Science (This will be guided by faculty in Offline mode)*

**BMS 405 A:** https://www.coursera.org/learn/ai-for-everyone/home/welcome

**BMS 405 B:** https://www.coursera.org/learn/introduction-to-ai/home/welcome

**BMS 405 C:** https://www.coursera.org/learn/iot-wireless-cloud-computing/home/welcome

**BMS 405 D:** https://www.edx.org/course/blockchain-advancing-decentralized-technology

**BMS 405 E:** https://www.coursera.org/learn/interactive-computer-graphics/home/welcome

## (BMS501) Core Course (CC 11): Thin films and Nano Materials

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

### COURSE OBJECTIVE

This course will provide an overview of nanostructures showing their fascinating properties unseen otherwise. The hierarchical development from nano to macro length scale, its adoption in nature (biomimicking), understanding the change in crystal structure. The course will teach the techniques of fabrication of different thin film materials.

**Course Content**

1. **Nanomaterials:** Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Overview of Nanostructures and Nanomaterials: classification, Crystalline nanomaterials and defects therein. Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation - Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

   **Online 10L**

2. **Synthesis of Nanostructure Materials:** Top down and Bottom up approach, Photolithography, Ball milling, Gas phase condensation, Vacuum deposition, Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition, Chemical vapor deposition (CVD), Sol-Gel, Electrodeposition, Spray pyrolysis, Hydrothermal synthesis, Preparation through colloidal methods, MBE growth of quantum dots.

   **Offline 10L**

3. **Growth and structure of films:** General features. Nucleation theories Effect of electron bombardment on film structure. Post- nucleation growth Epitaxial films and growth. Structural defects. Preparation methods: Electrolytic deposition, cathodic and anodic films, thermal evaporation, cathodic sputtering,

   **Online10L**

4. **Vacuum science and techniques:** Vacuum principles; Vacuum generation - Rotary vane pump, Diffusion Pump, Turbomolecular Pump (TMP), Cryo-Pump; Vacuum measurement - Thermal conductivity vacuum gauges, Ionization vacuum gauges. Surfaces and interfaces in nanostructures. Ceramic interfaces, Superhydrophobic surfaces, Grain boundaries in Nanocrystalline materials, Defects associated with interfaces

   **Offline 20L**

### LEARNING RESOURCES:

1. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications: Guozhong Cao and Ying Wang, 2nd Edition 2011, World Scientific
2. Introduction to Nanotechnology: Charles P. Poole, Frank J. Owens, 2007, Wiley
3. Introduction to Nanoscale Science and Technology: Massimiliano Di Ventra, Stephane Evoy and James R. Heflin Jr., Springer

**Course Outcomes (COs):**

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

| CO No. | Course outcomes |
|---|---|
| CO-1 | Understand the nanostructures along with their fascinating properties |
| CO-2 | Know and apply the synthesis routes for nanostructured materials |
| CO-3 | Analyse and apply techniques for growth of thin films on substrate like ceramic etc. Analyses of defect mechanism at the interfaces. |

**CO-PO Mapping:**

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

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

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

**(BMS 502) Core Course (CC 12): Materials Behavior: Electronic and Optical**

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

## COURSE OBJECTIVE

This course will develop knowledge on the fundamental principles of electronic band structure, solid state physics, and electricity and optics. These principles will help to describe the origins of the electronic and optical properties of materials. Also, it and how these properties can be engineered to suit particular applications, including diodes, optical fibers, LEDs, and solar cells.

**Course Content**

**1. Electronic Band Structures:** Periodic Potential, Central Equation, Understanding Band Diagrams, Engineering conductivity in Semiconductors. **Offline 10L**

**2. Solid-State Devices:** Introduction to PN Junctions, Solar Cells, LEDs and their applications

**Online 16L**

**3. Optical Properties:** Wave Equation, E/M Waves at Interfaces, Photonic Crystals. Importance of Optical Fiber communication, different types of Fiber, Rays Modes, Step-Index Fiber Structure, Ray optics representation

**Offline 16L**

**4.Wave Representation** in a Dielectric Slab Waveguide Light Emitting Diodes (LEDs); structure, materials. Luminescence. Photoconductivity

**Online 6L**

## LEARNING RESOURCES:

1. Electronic, Magnetic, and Optical Materials (Advanced Materials and Technologies)-Pradeep Fulay & Jung-Kun Lee, CRC Press, Taylor & Francis Group.
2. Hyperlink: https://www.edx.org/course/electronic-optical-magnetic-properties-mitx-3-024x

## Course Outcomes (COs):

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

| CO No. | Course outcomes |
|---|---|
| CO-1 | Introduce the concept of Wave equation, electromagnetic wave and its correlation with optical and electrical properties of material |
| CO-2 | Understanding the basics of optical properties and apply for device application |
| CO-3 | Device application of electronic and optical properties of mater and structure-property correlation. |

**CO-PO Mapping:**

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

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

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

**(BMS 504) Discipline Specific Elective I (DSE 2) (Choose any one of BMS 504 A/B/C/D/E/F)**

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

**BMS 504 (A) Bio-materials:**

Introduction: Definition of biomaterials, requirements & classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Surface properties of materials, physical and mechanical properties. Metallic implant materials: Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Hard tissue replacement implant: Orthopedic implants, Dental implants. Soft tissue replacement implants. Definition of bio ceramics. Common types of bio ceramics: Aluminum oxides, Glass ceramics, Carbons. Bio resorbable and bioactive ceramics. Importance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction). Polymers filled with osteogenic fillers (e.g. hydroxyapatite). Biocompatibility & Toxicological screening of biomaterials: Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies (in situ implantation, tissue culture, hemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.

**LEARNING RESOURCES:**

1. Biomaterials Science: An Introduction to Materials in Medicine, By Buddy D. Ratner, et. al. Academic Press, San Diego, 1996.
2. J B Park, Biomaterials – Science and Engineering, Plenum Press, 1984.

**BMS 504 (B) Energy materials:**

Introduction and overview, operating principle, polarization curves, components,types of fuel cell, low and high temper ature fuel cells, fuel cell stacks. Thermodynamics of fuel cell: application of the first and second law to fuel cells, signifi cance of the Gibbs free energy, concept of electrochemical potential and emf, Nernst equation, thermodynami c efficiencies of fuel cell in comparison to Carnot efficiencies, thermodynamic advantage of electrochemical energy co nversion Electrochemistry of fuel cell: electrochemical cells, oxidation and reduction processes, half-cell potentials and the electrochemical series, Faraday's law, faradaic and nonfaradaic processes, current and reaction rate, Fuel cell technology: Types of Fuel Cells, Power management, Thermal management; Fuel cell electro lytes: different types of electrolytes used, ionomeric membrane in PEFC, mechanism of ion transfer in ionom eric membranes, relation between proton conductivity and water content, alternative membranes Hydrogen Production: fossil fuels, electrolysis, thermal decomposition, nuclear, photochemical, photocatalytic, hybrid; Hydrogen Storage: Metal hydrides, chemical hydrides, carbon nano-tubes; Hydrogen as an alternative fuel in IC engines; Suitability of Hydrogen as a fuel, and techno-economic aspects of fuel cell as energy conversion device; Hydrogen fuel for transport. Solar cells, Organic Solar cell, DSSC; electrochemical supercapacitors with carbon electrodes; pseudo capacitor electrodes and supercapacitors; Hybrid supercapacitor

**LEARNING RESOURCES:**

1.Electrochemical Power Sources, vladimir s. bagotsky, alexander m. skundin, yurij m. volfkovich (2015), Wiley
2. Bard A. J., Faulkner L. R., Leddy J., and Zoski, C. G. (1980).
3. Electrochemical methods: fundamentals and applications (Vol. 2), Wiley

**BMS 504 (C) Polymeric Materials**: Introduction to polymeric materials. Mechanical behavior of polymers. stress–strain behavior. Macroscopic deformation. Viscoelastic deformation. Fracture of polymers. Mechanisms of deformation and for strengthening of polymers. Deformation of Semi crystalline Polymers. Factors that Influence the Mechanical Properties of Semi crystalline Polymers. Materials of Importance—Shrink-Wrap. Polymer Films. Degradation of polymers. Conducting Polymers. Biopolymers (Polylactic acid etc.). Glass Transition Temperature. Theories and Molecular motion. Factors affecting Glass Transition Temperature. Polymer additive and reinforcements. Polymer properties and applications

**LEARNING RESOURCES:**

1. Polymer Science and Technology, Robert O. Ebewele University of Benin, CRC Press LLC, New York
2. Mechanical Behaviour of Engineering Materials, J. Rösler · H. Harders · M. Bäker, Springer

**BMS 504 (D) Composites materials**: Introduction to composite materials along with its basic requirements and classification; Various models analyzing the design and performance of composite materials; Understanding the composite modulus, strength and fracture behaviour for structural applications. Composites including nano-composites for electrical, superconducting and device applications; Fabrication and processing of metal matrix (MM). Polymer Matrix (PM) and ceramic matrix (CM) composites and their characterization; Fabrication of nano-composites. Secondary processing and joining of various composite materials for structural applications and their fracture behavior and safety.

**LEARNING RESOURCES:**

1. V.V. Vasiliev and E.V. Morozov, Mechanics and Analysis of Composite Materials, Elsevier Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 IGB, UK.
2. K.K. Chawala, Ceramic matrix composites,1st ed., Chapman & Hall, London.
3. G. Piatti, Advances in composite materials, Applied Science Publishers Ltd., London

**BMS 504 (E) Metallic Materials**:

Introduction to metallic materials. Concepts of Stress and Strain, Elastic Deformation, Stress–Strain Behavior, Anelasticity, Elastic Properties of Materials, Plastic Deformation, Tensile Properties, True Stress and Strain, Elastic Recovery After Plastic Deformation, Compressive, Shear, and Torsional Deformation, Hardness, property variability and design/safety, factors variability of Material Properties, Design/Safety Factors.

**LEARNING RESOURCES:**

1. G.E. Dieter, "Mechanical Metallurgy", McGraw-Hill, 1986.
2. Mechanical Behavior of materials – Thomas H. Courtney
3. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976.

**BMS 504 (F) Ceramic Materials**:

Introduction to ceramic materials. Ceramic structures. Crystal Structures. Silicate Ceramics. Glasses. Glass–Ceramics. Clay Products. Refractories. Abrasives. Cements. Carbon. Advanced Ceramic Imperfections in Ceramics. Diffusion in Ionic Materials. Ceramic Phase Diagrams. Mechanical properties. Brittle Fracture of Ceramics. Stress–Strain Behavior. Fatigue. Creep. Fracture. Manufacturing of ceramics. Mechanism of crack propagation. Strengthening ceramics. Processing of Ceramic Materials

**LEARNING RESOURCES:**

1. Mechanical Behaviour of Engineering Materials, J. Rösler · H. Harders · M. Bäker, Springer
2. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976
3. Materials Science and Engineering – William D. Callister, Jr
4.. Materials Science and Engineering, A First Course – V. Raghavan

**Laboratory I: Nano Materials Lab (BMS 591)** **L-T-P: 0-0-4 (Credit - 2)**

1. Synthesis of Metal/Metal Oxide Nanoparticle using different techniques.
2. Characterizations using UV visible spectrophotometer, FTIR, X-ray Analysis.
3. Synthesis of Polymeric Nanocomposite.
4. Synthesis of a polymer composite
5. Synthesis of a semiconductor nanoparticles by chemical method
6. Preparation of metal oxide semiconductor thin film
7. Electrical transport properties of polymer composite
8. To determine the strength of different echant solution

**Laboratory II: Materials Behavior Lab (BMS 592)** **L-T-P: 0-0-4 (Credit - 2)**

1. To study the electronic property of Si based materials
2. To study the I-V characteristics of a diode
3. Determination of optical absorption characteristics
4. To study the grain boundaries of the materials under optical microscope
5. To study the phase present at the interface of the metal-ceramics composite
6. To study the interface under optical microscope of metal-metal joint interface
7. Determination of efficiency of a solar cell/electrochemical cell
8. To study the Band Gap Measurement of semiconductor
9. Determination of Refractive index by Abbe refractometer of different liquid samples
10. To determine the structure of the coiled wire after it gets tear with the application of load

**Sessional (BMS 581)** **Project Work** **L-T-P: 0-0-6 (Credit - 3)**

Project would be to do some preliminary works that would lead to the detailed project work spanning over Semester V and VI. Seminar presentation would be made by an individual student, and a report would have to be submitted by each student separately.

**SEMESTER – VI**

## (BMS 601) Core Course (CC 13): Materials Characterization

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

### COURSE OBJECTIVE

To explain different tools and techniques for characterization of different materials. The course will make the students know the working principle of the characterization instruments used to know the change in the property of the materials as their structure changes

**Course Content**

1. Materials characterization - definition; importance and application. Principles and general methods of compositional, structural and defect characterization.

**Offline 16L**

2. Microscopy techniques: Optical microscopy. Scanning electron microscopy (SEM). Transmission electron microscopy (TEM).

**Online 10L**

3. Optical and Electron spectroscopies - UV, visible, IR and Raman spectroscopies. Auger and photoelectron spectroscopies Optical characterization techniques: Absorption, transmission, reflection, Fourier transform infrared spectroscopy (FTIR), Photoluminescence, Raman. X-ray photoelectron spectroscopy (XPS).

**Offline 6L**

4. Rutherford characterization techniques backscattering spectrometry (RBS).

**Offline 10L**

5. Mechanical methods: measurement of tensile & flexural moduli, strength, fatigue, creep, fracture toughness, hardness etc.

**Offline/Online 10L**

### LEARNING RESOURCES:

1. Characterization of Materials, (2 Volume Set), E. N. Kauffmann (Editor)
2. Physical Principles of Electron Microscopy- R. F. Egerton
3 Materials Characterization-Yang Lang

### Course Outcomes (COs):

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

| CO No. | Course outcomes |
|---|---|
| CO-1 | Understand the concepts of characterization technique, principle of operation |
| CO-2 | Thorough knowledge base regarding the characterization routes of microscopy, optical, mechanical etc |
| CO-3 | Analyze the concept of material characterization for new materials and device application |

**CO-PO Mapping:**

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

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

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

## (BMS 602) Core Course (CC 14): Design and Selection of Materials

**L-T-P: 5-1-0 (Credit - 6)**

### COURSE OBJECTIVE

Material selection is a step in the process of designing any physical object. The course will teach how to design a product so as to minimize cost while meeting product performance goals.

**Course Content**

1. Selection of materials as selection of function, shape and process,

   **Offline 20L**

2. Evolution of engineering materials, flow chart for designing of materials, Design and Materials Selection Examples

   **Online 6L**

3. Design involving a new idea or working principle, Applications, redesign or reselection of materials to avoid mis use of materials

   **Offline 20L**

4. General properties of metals, ceramics, polymers and composites, Role of shape factors in materials selection, materials behavior under extreme conditions; corrosion

   **Online 10L**

5. Discussion of design and materials selection strategy; processing and process selection strategy

   **Offline 20L**

### LEARNING RESOURCES:

1. M.F.Ashby, Materials Selection in Mechanical Design, 4th edition, Elsevier, San Francisco, 2011
2. Materials Selection for Design and Manufacturing: Theory and Practice, Joseph Datsko
3. Materials Selection and Design, Springer, Md Abdul, Salit, Mohd Sapuan, ISBN 978-981-4560-38-2

### Course Outcomes (COs):

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

| CO No. | Course outcomes |
|---|---|
| CO-1 | Understand the techniques to design a product and cost minimization for best performance |
| CO-2 | Learn the techniques for selection of materials as a function of process, time etc |
| CO-3 | Implement the basic know how to design a material based on its application domain |

**CO-PO Mapping:**

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

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

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

**(BMS 604) Discipline Specific Elective 3 (DSE 4) (Choose any one of BMS 604 A/B/C/D/E/F except the course chosen in DSE 2)** **L-T-P: 3-1-0 (Credit - 3)**

**BMS 604 (A) Bio-materials:**

Introduction: Definition of biomaterials, requirements & classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Surface properties of materials, physical and mechanical properties. Metallic implant materials: Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Hard tissue replacement implant: Orthopedic implants, Dental implants. Soft tissue replacement implants. Definition of bio ceramics. Common types of bio ceramics: Aluminum oxides, Glass ceramics, Carbons. Bio resorbable and bioactive ceramics. Importance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction). Polymers filled with osteogenic fillers (e.g. hydroxyapatite). Biocompatibility & Toxicological screening of biomaterials: Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies (in situ implantation, tissue culture, hemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.

**LEARNING RESOURCES:**

1. Biomaterials Science: An Introduction to Materials in Medicine, By Buddy D. Ratner, et. al. Academic Press, San Diego, 1996.
2. J B Park, Biomaterials – Science and Engineering, Plenum Press, 1984.

**BMS 604 (B) Energy materials:**

Introduction and overview, operating principle, polarization curves, components,types of fuel cell, low and high temper ature fuel cells, fuel cell stacks. Thermodynamics of fuel cell: application of the first and second law to fuel cells, signifi cance of the Gibbs free energy, concept of electrochemical potential and emf, Nernst equation, thermodynami c efficiencies of fuel cell in comparison to Carnot efficiencies, thermodynamic advantage of electrochemical energy co nversion Electrochemistry of fuel cell: electrochemical cells, oxidation and reduction processes, half-cell potentials and the electrochemical series, Faraday's law, faradaic and nonfaradaic processes, current and reaction rate, Fuel cell technology: Types of Fuel Cells, Power management, Thermal management; Fuel cell electro lytes: different types of electrolytes used, ionomeric membrane in PEFC, mechanism of ion transfer in ionom eric membranes, relation between proton conductivity and water content, alternative membranes Hydrogen Production: fossil fuels, electrolysis, thermal decomposition, nuclear, photochemical, photocatalytic, hybrid; Hydrogen Storage: Metal hydrides, chemical hydrides, carbon nano-tubes; Hydrogen as an alternative fuel in IC engines; Suitability of Hydrogen as a fuel, and techno-economic aspects of fuel cell as energy conversion device; Hydrogen fuel for transport. Solar cells, Organic Solar cell, DSSC; electrochemical supercapacitors with carbon electrodes; pseudo capacitor electrodes and supercapacitors; Hybrid supercapacitor

**LEARNING RESOURCES:**

1. Gupta R. B. (2008); Hydrogen Fuel: Production, Transport and Storage, CRC Press
2. Bard A. J., Faulkner L. R., Leddy J., and Zoski, C. G. (1980).
3. Electrochemical methods: fundamentals and applications (Vol. 2), Wiley

**BMS 604 (C) Polymeric Materials**: Introduction to polymeric materials. Mechanical behavior of polymers. stress–strain behavior. Macroscopic deformation. Viscoelastic deformation. Fracture of polymers. Mechanisms of deformation and for strengthening of polymers. Deformation of Semi crystalline Polymers. Factors that Influence the Mechanical Properties of Semi crystalline Polymers. Materials of Importance—Shrink-Wrap. Polymer Films. Degradation of polymers. Conducting Polymers. Biopolymers (Polylactic acid etc.). Glass Transition Temperature. Theories and Molecular motion. Factors affecting Glass Transition Temperature. Polymer additive and reinforcements. Polymer properties and applications

**LEARNING RESOURCES:**

1. Polymer Science and Technology, Robert O. Ebewele University of Benin, CRC Press LLC, New York
2. Mechanical Behaviour of Engineering Materials, J. Rösler · H. Harders · M. Bäker, Springer

**BMS 604 (D) Composites materials**: Introduction to composite materials along with its basic requirements and classification; Various models analyzing the design and performance of composite materials; Understanding the composite modulus, strength and fracture behaviour for structural applications. Composites including nano-composites for electrical, superconducting and device applications; Fabrication and processing of metal matrix (MM). Polymer Matrix (PM) and ceramic matrix (CM) composites and their characterization; Fabrication of nano-composites. Secondary processing and joining of various composite materials for structural applications and their fracture behavior and safety.

**LEARNING RESOURCES:**

1. V.V. Vasiliev and E.V. Morozov, Mechanics and Analysis of Composite Materials, Elsevier Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 IGB, UK.
2. K.K. Chawala, Ceramic matrix composites,1st ed., Chapman & Hall, London.
3. G. Piatti, Advances in composite materials, Applied Science Publishers Ltd., London

**BMS 604 (E) Metallic Materials**:

Introduction to metallic materials. Concepts of Stress and Strain, Elastic Deformation, Stress–Strain Behavior, Anelasticity, Elastic Properties of Materials, Plastic Deformation, Tensile Properties, True Stress and Strain, Elastic Recovery After Plastic Deformation, Compressive, Shear, and Torsional Deformation, Hardness, property variability and design/safety, factors variability of Material Properties, Design/Safety Factors.

**LEARNING RESOURCES:**

1. G.E. Dieter, "Mechanical Metallurgy", McGraw-Hill, 1986.
2. Mechanical Behavior of materials – Thomas H. Courtney
3. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976.

**BMS 604 (F) Ceramic Materials**:

Introduction to ceramic materials. Ceramic structures. Crystal Structures. Silicate Ceramics. Glasses. Glass–Ceramics. Clay Products. Refractories. Abrasives. Cements. Carbon. Advanced Ceramic Imperfections in Ceramics. Diffusion in Ionic Materials. Ceramic Phase Diagrams. Mechanical properties. Brittle Fracture of Ceramics. Stress–Strain Behavior. Fatigue. Creep. Fracture. Manufacturing of ceramics. Mechanism of crack propagation. Strengthening ceramics. Processing of Ceramic Materials

**LEARNING RESOURCES:**

1. Mechanical Behaviour of Engineering Materials, J. Rösler · H. Harders · M. Bäker, Springer
2. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976
3. Materials Science and Engineering – William D. Callister, Jr
4.. Materials Science and Engineering, A First Course – V. Raghavan

**Laboratory I: Materials Characterization Lab (BMS 691) L-T-P: 0-0-4 (Credit - 2)**

1. Particle size analysis
2. Characterization of Materials through optical, XRD, SEM, TEM, FTIR and UV-VIS.
3. Measurement of electrical conductivity
4. Determination of Tensile strength, compressive strength, Microhardness and Abrasion Resistance.
5. Thermal analysis through TGA, DTA and DSC.
6. Measurement of electrochemical testing of cell

**Sessional (BMS 681) Project Work L-T-P: 0-0-6 (Credit - 3)**

This is the final project work compiling the total work of two semester V and VI. It has to be submitted in form of a bound thesis containing literature review, objective, details of work done, conclusion, reference, etc. Seminar presentation would be made by an individual student, and a report would have to be submitted by each student separately. The evaluation of the thesis will be done by a panel of examiners. Final presentation and viva voce of the project will be based on the project thesis submitted to be conducted by a panel of examiners with external invited member.