MASTER OF SCIENCE PROGRAM IN MATERIAL SCIENCE

Curriculum Proposal

Debre Berhan University,
College of Natural and Computational Sciences,
Physics Department and Chemistry Department

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Debre Berhan, Ethiopia

CURRICULUM PROPOSAL:

MASTER OF SCIENCE (MSc) PROGRAM IN MATERIAL SCIENCE (MS)

DEBRE BERHAN UNIVERSITY
COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

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DEBRE BERHAN, ETHIOPIA

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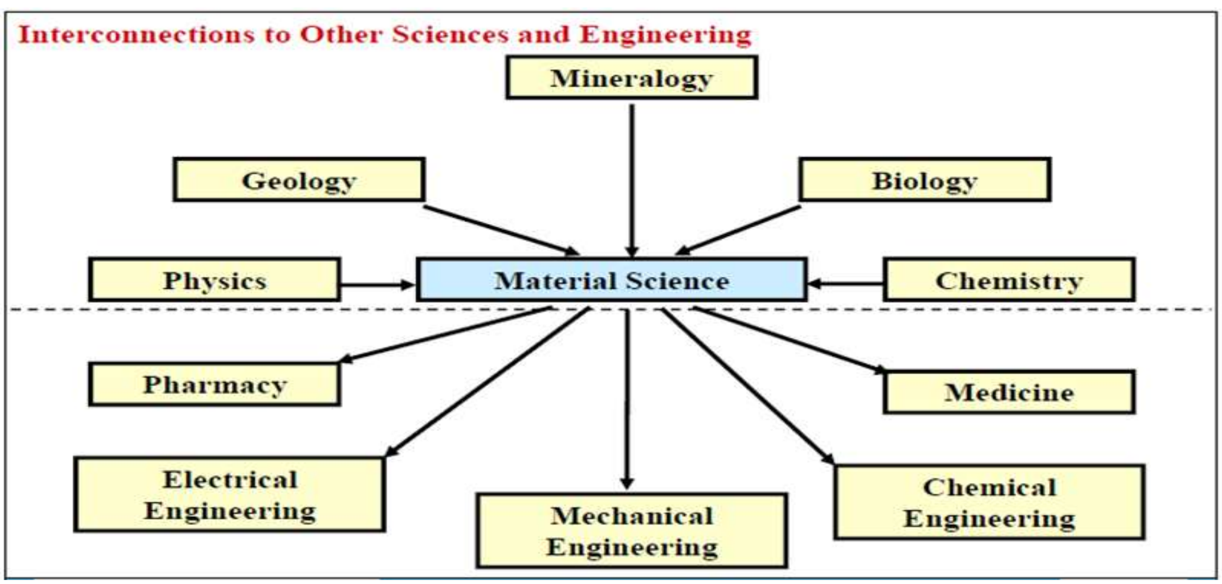
1. Introduction

1.1 Overview

The Physics and Chemistry Departments of Debre Berhan University, College of Natural and Computational Sciences, propose this ***MSc Program in Material Science*** based on an earlier need assessment done by the staff members of the college, the composition of the staff profile, as well as on the on-going research activities of the staff. This is a post graduate degree curriculum designed in a way so that the students admitted to the program acquire an in-depth knowledge in diverse areas of Material Science at the most fundamental as well as at the advanced level. After the completion of the course, the students are expected to gain enough competence and proficiency in the field, which would enable them to pursue research in Material Science, to take up teaching jobs in Universities and Colleges, and to get useful employment in any private or government institutions or manufacturing industries where knowledge of Material Science and Engineering is an essential requirement.



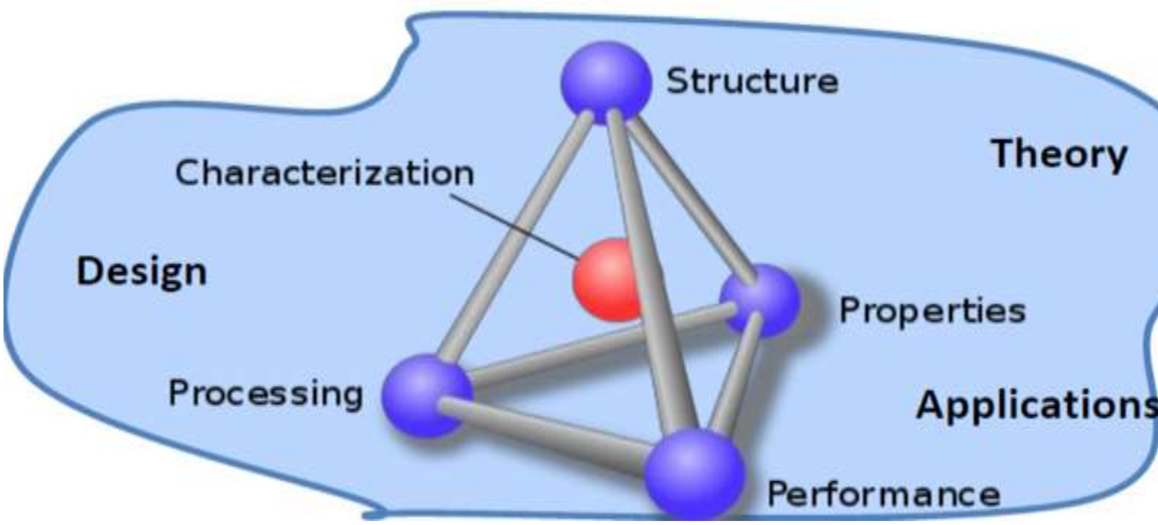
As a field, Material Science, which is nowadays being referred interchangeably as Material Science and Engineering, have roots in natural materials; and these fields have evolved to encompass minerals, metals, slags, alloys, glasses, ceramics, polymers, composites, thin films, biomaterials and nanomaterials.

In general, Material Science and Engineering deals with the fundamental understanding of materials through their design, development, and characterization regarding structure, properties, processing, and/or performance along with the underlying theoretical framework. Materials of interest range in size from nanoscale communications components and biomedical devices all the way to large-scale aerospace and energy products. Encompassing a very broad range of spatial scales, academic disciplines, and applications areas, the proposed MSc program will integrate key aspects of Research and Development (R&D) that is crucial for the sustainable development of our country.

Therefore, this curriculum is framed to serve the present and future needs in Ethiopia pertaining to electronics, electrical, mechanical, communication and industry sectors. As a matter of fact, this curriculum can be offered as a hybrid program involving one or more departments of physics, chemistry, mathematics, electrical, chemical and mechanical engineering. The program can be offered either collectively or individually by stressing on respective applications. However, the present program is developed with an emphasis on Applied Physics and Chemistry.

1.2 The Basis for Material Science

The basis for Material Science and Engineering is the study of ***properties*** of existing materials and their assessment, research leading to preparation and assessment of new materials, establishing cost-effective ***processes***, assessment of mechanical, electrical & optical properties, modeling for assessment of behavior & inventing new materials, space science, aeronautics and innumerable other branches. ***Performance***, ***characterization*** and ***structure*** studies play a dominant role. The study of defects and insertion of impurities in materials turned out to be interesting. For example, aluminum is not a strong material in its pure form but by introducing right defects like precipitates, grain boundaries, interstitial atoms, or substitutional atoms to strengthen solid solution in the correct quantity, high strength alloy is manufactured which is used in bicycles, automobiles, and airplanes. Certain impurities in minerals make them valuables. Glass becomes tougher with certain impurities. Presence of carbon and some other impurities in steel leads to high strength. Impurities introduced into silicon make p-type and n-type materials that led to invention of transistors, ICs essentially used in TVs, CD players and personal computers. Industrial applications of Material Science lead to new materials design, methods of managing of industrial materials, large scale processing techniques such as casting, rolling, welding, ion implantation, crystal growth, thin-film deposition, sintering, glassblowing, and various others.



Among the various topics that form the basis of Material Science and Engineering, we have the following:

1. Thermodynamics, statistical mechanics, kinetics and phase stability;
2. Crystallography, atomic bonding, lattice arrangement and characterization;
3. Mechanical properties of materials and their structural applications;
4. Solid-state physics for understanding electronic, thermal & optical properties of materials;
5. Diffraction and wave mechanics, for the characterization of materials;
6. Polymer science, for the understanding of polymers and plastics;

7. Aspects of integration of natural materials that lead to biological systems;
8. Quantum mechanical and statistical aspects, for the study of ensembles that are the basis for stable materials;
9. Computational methods for theoretical estimation of material property and assessment; and Modeling and simulation leading to preparation, stability and analysis of materials.

Since engineering and Material Science are the offspring of physics and chemistry, it is needless to say that the Physics and Chemistry Departments of College of Natural and Computational Sciences play a major role in streamlining "Material Science" as a new discipline.

1.3 Thematic Area of the Proposed Program

Traditional solid materials have been grouped into three basic categories: polymers, metals, and ceramics. In additions, there are composites, formed simply by combining two or more materials. Another category is advanced materials, i.e., those used in high-technology applications, such as semiconductors, biomaterials, and nanomaterials. However, within the broad intellectual footprint of Material Science and Engineering, the proposed Master's Program in Material Science and Engineering will concentrate on four overlapping and interacting areas, which are important to our country's economic interests. These are (1) Biomaterials; (2) Materials for Energy Storage, Conversion and Conservation; (3) Electronic, Photonic, and Magnetic (EPM) Materials; and (4) Materials synthesis, processing and fabrication.

In these areas, the two participating departments (the Department of Physics and the Department of Chemistry) already have significant faculty strength and ongoing research activities. These four research themes are described briefly below.

Biomaterials: This thematic area includes bio-inspired materials and the interactions between materials and biological systems. Biomaterials and bio-mimetics research investigates and bridges the gap between benchtop investigations and clinical applications with the goal of improving health worldwide. Other important applications are in environmental sensors and bio-inspired or bio-compatible structural materials.

Materials for Energy Storage, Conversion and Conservation. A cornerstone of the Material Science and Engineering Program is the fundamental and applied research in the area of materials for energy storage, conversion, and conservation. Broadly, this research area focuses on transforming resources such as sunlight, wind, and biomass into fuels that can be used at later times to provide reliable, electrical power. Research underway addresses critical materials issues for developing sustainable means of producing and storing chemical fuels, improving energy efficiency, and for converting Ethiopia's abundant natural and renewable resources into a clean, economical, and unlimited supply of electrical power.

Electronic, Photonic, and Magnetic Materials. Electronic, photonic, and magnetic (EPM) materials have applications in quantum information and cryptography, information storage, signal processing, communications, electronics, imaging and sensing techniques, and laser components. These materials are studied in nanoparticle, thin-film, bulk, and single-crystal form and also in optical waveguides and other device configurations. Theoretical directions are quite diverse, and they include determination of structure/function relationships, electronic structure calculations, optical energy levels plus coherence and spin dynamics for ions, properties of alloy phases, and unique phases of matter.

Materials Synthesis, Processing, and Fabrication. This focus area encompasses an exceptionally broad range of research that extends all the way from the extraction and refining of bulk materials to the synthesis of high value-added advanced nanomaterials with application-specific properties. Success in the broad arena of materials processing requires a multi-disciplinary approach. The collaborative Program pools expertise in solid state physics, polymer chemistry, Nano-composites, and Process Engineering to conduct research that responds to and anticipates current and emerging industrial needs and interests.

2. Rationale of the Program

Developing countries have adjusted their industrial policies to make use of new advances in Material Science and Engineering so as to help maximize their development. Ethiopia cannot afford remaining sitting behind. Our country needs R&D for sustaining its growth and transformation plan. Traditionally, Ethiopia is used to export raw materials and import manufactured goods, with the manufacturing sector only accounting for about 5% of the GDP. Currently, the government is working to change this situation. Materials for secondary manufacturing industries and service sectors are planned to be produced locally. For example, cement factories are encouraged to produce the materials necessary for the construction segment. To this end, the Ministry of Finance and Economic Development has authored countrywide strategic documents known as the Growth and Transformation Plans (GTP I and GTP II), with GTP I setting out the goal that all new universities "will be furnished with the equipment necessary and encouraged to give priority to science and technology and teacher development programs." GTP II, being under implementation, approaches Material Science and Engineering as an essential area to develop and improve in Ethiopia. Therefore, as Material Science and Engineering programs such as this one grow and students graduate and research progresses, the science will produce the knowledgeable critical mass and materials that will develop and improve Ethiopia in return. Skilled and confident graduates in ceramics, metallurgy, semiconductors, polymers, and so on are the key for technology transfer and adaptation in the short term and development of indigenous technology in the long term.

The future trend of the country in the education sector promotes science and technology with a policy that guarantees a share of 70% of the candidates for tertiary education. This demands a substantial number of students seeking for post graduate studies in science in general and Material Science and Engineering in particular. Therefore, this newly proposed MSc program can also serve to satisfy the demand of qualified manpower in the currently opened universities all over the country.

Moreover, the result of the need assessment conducted on the various organizations, which usually absorbs MSc graduates in Material Science and Engineering strongly dictates the commencement of such programs. What we have learnt from the Need Assessment is that there is a high demand in the country for MSc Graduates with a good background in Material Science and Technology. In this regard, the summary of the need assessment is shown as stipulated in *table- 1* below.

Therefore, this MSc Curriculum in Material Science has been designed with the above justifications in mind.

Name of Organization/Group participating in the Need Assessment	**Consented for Practical & Research work**	**Employment Prospect**	**Overall Relevance**
Ministry of Science & Technology	very high	very high	very high
Ethiopian Standards and Quality Authority	very high	very high	very high
Ethiopian Radiation Protection Authority	very high	very high	very high
Ethiopian Meteorology Agency	very high	very high	very high
Geological Survey of Ethiopia	very high	very high	very high
The Ethiopian Civil Aviation Authority	very high	very high	very high
Adama and Addis Ababa Science and Technology Universities	very high	very high	very high
DBU Chemistry and Physics Graduates	very high	very high	very high

table- 1 Summary of the Need Assessment done on selected possible employers and graduate students of the physics and chemistry departments of DBU

3. Objectives of the Program

3.1 General Objectives

The MSc program in Material Science is designed to produce the skilled manpower required to meet the national demand in the various industrial sectors such as: mining & minerals, energy, water exploration, metallurgy, electronic device fabrication, construction, telecommunications and several other industries. The program will contribute to meeting the shortage of skilled manpower in various manufacturing industries and research laboratories and will play its own role in poverty reduction in the country.

3.2 Specific Objectives

The specific objectives are to:

- Apply advanced concepts of fundamental sciences and engineering to identify, formulate and solve complex materials and devices problems, to meet desired needs of society professionally and ethically;
- Design and conduct experiments in the area of materials and/or devices using advanced approaches, and analyze and interpret data;
- Use advanced materials characterization techniques, skills, and modern scientific and engineering tools.; and
- Provide advanced training on specialized and emerging topics of Material Science.
- Provide professional and expert advice for policy makers on general and specific topics about emerging materials that are relevant to the country's industrial sector based on scientific research.

4. Graduate Profile

A graduate in the Material Science Program has the necessary knowledge, skill and attitude in solving problems pertaining to Material Science, can identify research area, design and conduct research in the field, and can work as a senior level professional in the field, and can also communicate effectively in written and oral form, both, individually and as a member of a multidisciplinary team

5. Professional Profile

A Material Science graduate can look forward to limitless employment opportunities in a substantive array of industries. Most companies nationwide and worldwide employ materials professionals. A Material Science/technology degree opens doors to jobs in industries, and provides knowledge of manufacturing, processing and the fabrication of materials in a range of rewarding careers. Job options directly related to this degree, inter alia, include: Materials Engineering, Metallurgy, Product/Process Development, Research and Development (Physical Sciences), Biomedical Engineering, Higher Education (Lecturer), Manufacturing Systems Engineering, Patent Examining, Pharmaceuticals, Health Care and Construction, as well as in areas related to materials designing, production, transformation and control, and Quality Management.

Wherefore, after the completion of this MSc Curriculum in Material Science, the graduates are capable to undertake duties and responsibilities:

- in Science and Technology agency;
- in the Energy and Environment sector;
- as Lecturers in Universities and Colleges;
- in collecting, analyzing and interpreting geophysical data;
- in Space Science Research;
- in the areas of Material Science Technology and Manufacturing Industry;

- in the Radiation Protection Agency;
- in the area of Meteorology
- in the Agency for Standardization and National Quality Control;
- in the media as Material Science Communicator;
- working in the area of Electronics and Energy as a private employee;
- undertaking research for further studies and PhD in Material Science and Technology related areas.

6. Teaching-Learning Method & Grading System

6.1 Methodology of Teaching:

In the MSc program, selected advanced Material Science courses and advanced teaching methodologies in Material Science are included. All courses are to be offered in a student centered manner so that the students get exposed to all the important aspects of material science, and acquire detailed knowledge of the front-line areas of the field. Seminar presentations, writing term papers, doing assignments, peer collaboration, developing teaching and research skills, will form an integral part of the course work which can be used as a means of continuous assessment.

Presentation of courses is through lectures, tutorials, self-study (project works), problem solving, class and group discussions, assignments, laboratory demonstrations and hands-on exercises as well as quizzes and tests to insure continuous assessment and student/learner centered approach.

6.2 Attendance Policy:

Regular, punctual class attendance is essential for the satisfactory completion of a course. Each student is expected to attend at least 85% all the sessions, complete all assigned work, and take all examinations. Failure to do so may not be tolerated under normal circumstances, and the ruling will be as per the legislation of the University.

6.3 Continuous Assessment:

Assignments, report, end-of-semester examinations, projects, etc. with their percentage contribution to the final assessment will be followed as per the legislation of the University and will be distributed by the instructor with a detailed course guidebook which will be available to students before the course begins.

6.4 Mode of Evaluation of Course Work

Since maximum effort should be done to achieve the stated objectives of the curriculum, there is a need for a fixed scale grading system. In order to assure fair grading, a letter grading system will be assigned as stipulated by the legislation of the University. Therefore, examinations are graded on the following letter grading scheme with corresponding points.

Raw Mark	Letter Grade
[90, 100)	A+
[85, 90)	A
[80,85)	A-
[75,80)	B+
[70,75)	B
[65,70)	B-
[60,65)	C+
[50,60)	C
< 50	F

6.5 Mode of Evaluation for Thesis / Graduate Project

A thesis/graduate work shall constitute an individual's effort in academic pursuits to identify and analyze problems by applying sound methodology. A thesis/graduate work shall constitute a partial fulfillment of the requirement for the Master's Degree. Based on the aggregate assessment of a Board of Examiners out of 100%, the Ranking of the thesis/project that appears on the certificate will be either "***Excellent***", or "***Very Good***", or "***Good***", or "***Satisfactory***", or "***Fail***".

6.5.1 Selection and Approval of Thesis Topic

1. The topic for thesis work shall be selected in consultation with, and prior approval of, the thesis advisor. The selection of thesis topic shall be on the basis

of the broad needs of the country and/or the priority areas of research topics as determined by the concerned academic unit.

2. The topic of the thesis/graduate project of each candidate shall be approved by the DGC as early as possible and not later than the time of the candidate's enrollment into the second half of the program.

6.5.2 Format of Thesis

The format for thesis write-up will be as per the legislation of the University. Academic Standards and Quality Assurance Committee (ASQAC) format will be followed for detailed guidelines on Thesis preparation, format, deadlines, etc.

6.5.3 Time for Submission of Thesis

A candidate may submit the thesis at any time after the last semester of course work and no later than four weeks before the end of the fourth semester with the exception of candidates allowed for extended time.

6.5.4 Procedure for Inspection and Submission of Thesis

When a candidate, after conferring with the advisor, gives notice of readiness to submit a thesis, the DGC shall appoint an Examining Board and select an External Examiner. The External Examiner should be decided in good time and obtain a copy of the thesis of the candidate at least four weeks before the date set for the defense. The Board shall have three members consisting of at least one other member of the College of Natural and Computational Sciences. All members of the examining Board will comment on all aspects of the thesis.

6.5.5 Thesis Evaluation Weight

(a) Abstract .... (5%)

(b) Introduction, Literature Review ... (10%)

(c) Materials and Methods .... (15%)

(d) Result and Discussion .... (40%)

(e) Summary and Conclusion .... (10%)

6.5.6 *Open Defense Evaluation Weight*

(a) Manner of presentation .... (5%)

(b) Confidence in the subject matter .... (5%)

(c) Ability of answering questions .... (10%)

6.5.7 *Evaluation Aggregate Result and Final Thesis Rank*

After each Board Member takes its own evaluation out of 100%, the Evaluation Aggregate Result out of 100% will be calculated and then the thesis is ranked as follows.

$$* \, Evaluation\ Aggregate\ Result\ (\%)$$
$$= 0.5\ X\ External\ Examiner's\ Result$$
$$+ 0.35\ X\ Internal\ Examiner's\ Result + 0.15\ X\ Advisor's\ Result$$

*Evaluation Aggregate Result (%)	Rank
≥ 85	Excellent
75 ≤ X < 85	Very Good
60 ≤ X < 75	Good
50 ≤ X < 60	Satisfactory
< 50	Fail

6.5.8 *General Remark about the Thesis*

Based on the Evaluation Aggregate Result of the Board of Examiners, the thesis that is defended shall be remarked as follows:

I. **Accepted:** The Thesis is: -

a. Accepted with no change,

b. Accepted with minor changes to be made to the satisfaction of the advisor, or Accepted with major modification to be made to the satisfaction of the external examiner and the rest of the Board of

Examiners. Under certain circumstances the external examiner may delegate the Board of examiners If a thesis requires substantial changes in substance, which are to be made to the satisfaction of members of the examining Board or its designate, the examining Board's report shall include a brief outline of the nature of the changes required and indicate the time by which the changes are to be completed.

II. **Rejected: -** A thesis shall be rejected if:

a. The work does not meet the required standards; or
b. The work is plagiarized as judged by the examining Board; or
c. The work has been already used to confer a degree from this or another University. However, this shall not preclude the candidate from submitting such work provided enough extra work has been done to expand the scope and depth of the subject.

7. Academic Requirements

7.1 Admission Requirements

Students entering the program will be drawn predominantly from backgrounds in engineering and the basic sciences. Therefore, B.Sc. Graduates having a degree in Material Science or Applied Physics or Applied Chemistry or Electrical Engineering or Chemical Engineering or Mechanical Engineering who qualify in an entrance exam conducted by the University on the basis of merit are admitted. The exact admission criteria are stipulated by the University. It should be noted here that the Master of Science Program in Material Science builds on the background that is acquired during the Bachelor of Science studies.

7.2 Graduation Requirements

The basics that has been acquired in an under grad science or technology degree are expanded in core courses of this program, while a broad choice of further courses allows for an individual specialization. Compared to the Bachelor program, the core courses convey general topics in materials in a broader context, for example surface properties, biocompatibility, transport phenomena, materials selection and materials design. This knowledge enables the problem-oriented approach that characterizes a materials scientist.

The core courses are complemented by a free choice of courses out of the Master programs. This facilitates setting an additional focus, be it in materials characterization, computational methods or micro- and nanotechnology. The theoretical knowledge is applied and enhanced in a six-month Master thesis or Project work, which are typically carried out in one of the College's Material Science Research groups.

The minimum number of required course work to accomplish for the MSc degree:

7.2.1 With Thesis

- 31 Cr. Hrs. of Compulsory course work
- 3 Cr. Hrs. Elective course work
- 3 Cr. Hrs. Seminar on Advanced Material Science Topic
- 6 Cr. Hrs. Thesis in Material Science
- Should score at least a "satisfactory" rating in the Thesis or as stipulated in the University senate legislation.
- Course performance of CGPA greater than or equal to 3.00 with no more than one 'C' or as stipulated in the University senate legislation.

7.2.2 With Graduate Project

- 31 Cr. Hrs. of Compulsory course work
- 6 Cr. Hrs. of Elective course work
- 3 Cr. Hrs. Seminar on Advanced Material Science Topic
- 3 Cr. Hrs. Project Work in Material Science.
- Should score at least a "satisfactory" rating in the Graduate Project or as stipulated in the University senate legislation.
- Course performance of CGPA greater than or equal to 3.00 with no more than one 'C' or as stipulated in the University senate legislation.

8. Degree Nomenclature

Those candidates of MSc Degree in Material Science that successfully complete the program such that can satisfy the Graduation Requirements will be awarded the MSc degree up on approval by the Debre Berhan University Senate; and the degree shall be designated as:

English: **Master of Science Degree in Material Science**

Amharic: **የሳይንስ ማስተር ዲግሪ በማቴሪያል ሳይንስ**

9. Duration of the Study

Under normal circumstance, the program will be offered in two academic years. If a student wishes or forced to extend the duration, it will be ruled according to the legislation of the University. The specific courses that constitute an acceptable program for such situations must be approved in advance by the administering Department's GDC or by the AC of the College of Natural and Computational Sciences.

10. Administering Department

This graduate program in Material Science is coordinated through the GDC of the Department of Physics. So, students interested in Material Science should enroll in the Department of Physics. However, the GDC (or MS-UNIT to be formed) will promote the interdepartmental nature of the discipline and involves the advisory inputs from the Applied Chemistry, Chemical Engineering, Mechanical Engineering and, Electrical Engineering Departments.

11. Course Selection & Sequencing

11.1 Course Coding/Numbering

All Material Science courses are coded "MS" followed by three digits:

- The first digit indicates the level of the course: i.e.,
  - **5** for first year courses
  - **6** for second year courses
- The middle digit indicates the various streams of Courses, i.e.,
  - **0** for foundation courses such as Mathematical Methods, Computational Methods and Quantum Mechanics of Material Science.
  - **1** for the Laboratory and Practical Courses.
  - **2** for Statistical Thermodynamics related courses.
  - **3** for Core Material Science courses such as Fundamentals of Material Science, Polymer Chemistry, Semiconductor Physics, Solid State Physics, Introduction to Nanoscience and Technology, and Characterization and Analytical Techniques
  - **4** for Chemistry related elective courses.

5 for Physics related elective courses.

6 for Nanoscience related elective courses.

7 for Renewable Energy Materials, for Ceramics, Polymer, Biomaterial and related elective courses

8 for Materials Preparation and Spectroscopic Techniques

9 for Thesis/Graduate Project/Research Methodology & Scientific Writing/Seminar

- **The last digit stands for semester in which the course is offered** i.e.

  ODD - last digit courses are offered during the first semester.

  EVEN - last digit courses are offered during the second semester

11.2 Course Selection

11.2.1 Compulsory Courses

- Fundamentals of Material Science (MS531)
- Statistical Thermodynamics & Kinetics of Materials (MS521)
- Mathematical Methods for Materials Scientists and Engineers (MS501)
- Introduction to Nanoscience and Technology (MS533)
- Characterization and Analytical Techniques (MS535)
- Solid State Physics for Material Scientist (MS532)
- Polymer and Composite Materials (MS534)
- Semiconductor Materials and Devices (MS536)
- Materials Lab - I (MS512)
- Quantum Mechanics of Material Science (MS502)
- Materials Lab - II (MS613)
- Computational Methods for Materials Scientists and Engineers (MS601)
- Research Methods and Scientific Writing (MS691)
- Seminar on Advanced Material Science Topic (MS693)

11.2.2 List of Elective-I Courses

- MS681 Materials Preparation Techniques
- MS683 Spectroscopic Techniques for Materials
- MS661 Introduction to Micro & Nano Fabrication
- MS663 Science and Technology of Thin Films and Nanomaterials
- MS671 Biomaterials
- MS665 Carbon Nanotubes
- MS673 Ceramics Science and Technology
- MS675 Materials for Renewable Energy and Storage
- MS667 Graphene Physics

11.2.3 List of Elective-II Courses

- MS672 Physics and Chemistry of Polymers
- MS642 Analytical and Inorganic Chemistry
- MS644 Physical Chemistry
- MS652 Semiconductor Optoelectronics
- MS662 Nano-biotechnology in Health Care
- MS664 Nano-photonics

11.2.4 Summary of Course Requirements

1. All students from both options (i.e. Thesis Based and Graduate Project-Based) are required to take all the compulsory courses listed above.

2. All students from both options must take at least one additional elective course from the list '***Elective-I***'. The selection of the appropriate specialty elective course will be done in consultation with an assigned advisor

3. Graduate Project-Based (Non-thesis) students must take one more additional elective course from the list '***Elective-II***, which will be chosen again in

consultation with an advisor, and must conduct an independent Project in Material Science area.

4. Thesis-Based students must conduct an independent Master Thesis in Material Science.

11.2.5 Sequencing (Course Schedule)

Year I **Semester I**

Course Code	Course Title	Cr. Hrs	Lec Hrs	Tut Hrs	Lab Hrs
MS531	Fundamentals of Material Science	**3**	3	1	-
MS521	Statistical Thermodynamics & Kinetics of Materials	**3**	3	1	-
MS501	Mathematical Methods for Materials Scientists and Engineers	**3**	3	1	-
MS533	Introduction to Nanoscience and Technology	**3**	3	1	-
MS535	Characterization and Analytical Techniques	**2**	2	1	-
Total		**14**	14	5	-

Year I **Semester II**

Course Code	Course Title	Cr. Hrs	Lec Hrs	Tut Hrs	Lab Hrs
MS532	Solid State Physics for Materials Scientist	**3**	3	1	-
MS534	Polymer and Composite Materials	**3**	2	1	3
MS536	Semiconductor Materials and Devices	**3**	3	1	-
MS512	Materials Lab -I	**1**	1	-	3
MS502	Quantum Mechanics for Material Science	**3**	3	1	-
Total		**13**	9	3	6

Year II **Semester I**

Course Code	Course Title	Cr. Hrs	Lec Hrs	Tut Hrs	Lab Hrs
MS613	Materials Lab -II	**1**	1	-	3
MS601	Computational Methods for Materials Scientists and Engineers	**3**	3	-	3
MS691	Research Methods and Scientific Writing	**2**	2	-	-
MS693	Seminar on Advanced Material Science Topic	**1**	-	-	-
MS6XX	Elective- I	**3**	3	1	-
Total		**10**	9	1	6

Year II **Semester II**

Thesis-Based

Course Code	Course Title	Cr. Hrs	Lec Hrs	Tut Hrs	Lab Hrs
MS696	Master Thesis in Material Science	**6**	-	-	**-**
Total		**6**	-	-	-

OR

Graduate Project-Based

Course Code	Course Title	Cr. Hrs	Lec Hrs	Tut Hrs	Lab Hrs
MS6XX	Elective-II	**3**	-	-	**-**
MS694	Graduate Project in Material Science	**3**	-	-	**-**
Total		**6**	-	-	-

12. Details of the Courses (Syllabus)

12.1 Compulsory Courses

12.1.1 Fundamentals of Material Science (MS531)

Course Title:	Fundamentals of Material Science		
Code:	MS531		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hr.)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ______________________________			
Class Hours:			

Course Rationale

This course is intended for students who do not have a Material Science background. The course will cover four major topics including: fundamental concepts, microstructure development and phase equilibria, material properties and fabrication methods and applications.

Course Description

The course will cover atomic structure, atomic bonding, crystal structures, defects, and diffusion in materials. It also will cover phase transformations and phase equilibria and how they impact microstructure development. The electrical, magnetic, optical, thermal, and mechanical properties of materials will also be reviewed. The course will also highlight modern fabrication technologies and applications of metals, ceramics, semiconductors, and polymers.

Textbook

- William D. Callister, Jr. Material Science and Engineering: An Introduction, 5th or any other upgrade edition, John Wiley and Sons, 2000.

Reference Books

1. William F. Smith, Foundations of Material Science and Engineering, 3rd Ed., McGraw-Hill, 2004.
2. James F. Shackelford, Introduction to Material Science for Engineers, 5th Ed., Prentice Hall, 2000.
3. Larry D. Horath, Fundamentals of Material Science, 3rd Ed., Prentice Hall, 2006.
4. Donald E. Sands, Introduction to Crystallography, Dover Publications, (1994).
5. Darrell Irvine and Nicola Marzari, Fundamentals of Material Science, MIT Open Course Ware Publications (2005).

12.1.2 *Statistical Thermodynamics & Kinetics of Materials (MS521)*

Course Title:	Statistical Thermodynamics & Kinetics of Materials		
Code:	MS521		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

A multidisciplinary course covering:

THERMODYNAMICS AND KINETICS- applicable to phase changes and processing in broad range of Materials (metals, oxides, polymers, colloids, gels, surfactants). Phase equilibrium (including effects of curvature), nucleation, crystallization, phase separation, diffusion in liquids and solids, colloidal stability, flocculation and gelatin, glass transition.

CHEMICAL POTENTIAL- Helmholtz and Gibbs free energies, Thermodynamic reactions, Euler equation, Maxwell's relations and applications, Gibbs phase rule, phase equilibria (single and multi-component systems, Clausius–Clapeyron equation, law of mass action, first order phase transition in single component systems.

ENSEMBLES- Micro-canonical, canonical and grand canonical ensembles, Maxwell – Boltzmann, Bose- Einstein and Fermi-Dirac statistics, Comparison of MB, BE and FD statistics.

APPLICATION OF STATISTICS- Stefan-Boltzmann law, Einstein model of a solid, Bose condensation, Classical partition function and classical ideal gas, Equipartition theorem, Semiconductor statistics, Statistical equilibrium of free electrons in semiconductors.

HEAT AND MASS TRANSFER- Basic concepts of conduction, convection and radiation, Hydrodynamics, Dimensionless numbers, Rayleigh's Number, Reynold's number, Heat balance

Equation, Mass transfer convective flow, diffusion, Fick's law, diffusion coefficient, mass transfer coefficient, Application to melt growth.

Reference Books:

1. Eugene S. Machlin, An Introduction to Aspects of Thermodynamics and Kinetics Relevant to Material Science, 3rd Edition, 2007
2. Atkins' Physical Chemistry, 8th Edition, 2006
3. Robert W. Balluffi, Samuel M. Allen, W. Craig Carter, Kinetics of Materials; 2005
4. David R. Gaskell, Introduction to the Thermodynamics of Materials, 4th Edition.

12.1.3 Mathematical Methods for Materials Scientists and Engineers (MS501)

Course Title:	Mathematical Methods for Materials Scientists and Engineers		
Code:	MS501		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

This course covers the mathematical techniques necessary for understanding of Material Science topics such as energetics, materials structure and symmetry, materials response to applied fields, mechanics and physics of solids and soft materials. The class uses examples from the Material Science core courses to introduce mathematical concepts and materials-related problem solving skills. Topics include orthonormal basis, eigenvalues and eigenvectors, quadratic forms, tensor operations, symmetry operations, calculus of several variables, introduction to complex analysis, Vectors in crystals, Tensors in solid state physics (elastic and dielectric properties, transport properties), Differential equations: quantum states, distribution functions and thermal properties, Linear algebra and Eigen mode analysis (basics, applications), Dirac-Delta function, Fourier transformation and reciprocal space, Special functions in quantum mechanics, Variational method, Green's function and response functions,

Reference Books:

1. Edward Prince. Mathematical Techniques in Crystallography and Material Science, 3rd Edition. Springer, 1982.

2. Mathematical Methods of physics by G.B. Arfken and H.J. weber
3. Mathematical physics by B.D. Gupta
4. Matrices and tensors in physics by A.W. Joshi
5. Mathematics of Engineers and Physicists by Pipes

12.1.4 Introduction to Nanoscience and Technology (MS533)

Course Title:	Introduction to Nanoscience and Technology		
Code:	MS533		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Introduction to nanotechnology basics, definition. History of nanotechnology. Nanotechnology in relation to other branches of science. Structure of solids crystalline and non-crystalline. Types of common materials and advanced materials inorganic, organic, biologic. Types of nanomaterials depending upon their properties electronic, semiconductors, superconductors, super ionic, magnetic, optic, opto-electronic, spintronic, lasers, photonics, ceramics, bio ceramics, biomedical, biosensors, bio imagers, photocatalysts, quantum dots. Basic properties of materials and the instrumentation used to study these properties. Size effect of materials on properties. Quantization effect on the properties of materials with examples. Nanocomposites and their applications in modern technology. Carbon Nanotubes and other Nanotubes. Nanomaterials natural and synthetic. Nanocomposites and Nanohybrid materials. Nanomaterials synthesis techniques nano-engineering of materials. Bottom up and Top down routes. Solution, Melt and Gas Processing of nanomaterials. Nature inspired processes. Nanomaterials characterization X-rays, Spectroscopic - infrared, UV-Vis, Laser Raman, Photoluminescence, Electron Microscopic techniques, Thermal analysis, surface characteristics, light scattering methods, gas adsorption, magnetic susceptibility, conductivity, band gap calculations. Nanotechnology in modern technology in relation to electronic, biological, consumer and domestic applications. Applied nano-biotechnology and nano-biomedical science drug delivery, drug targeting, biosensors, bio-imaging, neutron capture therapy.

Reference Books:

1. Introduction to Nanoscience and Nanotechnology by Chris Binns, A JOHN Wiley & Sons Inc., Publication.
2. Introduction to Nanoscience & Nanotechnology by G.L. Hornyak, H.F. Tibbals, J. Dutta and J.J. Moore; CRC Press.
3. An Introduction to Nanoscience and Nanotechnology by Alain Nouailhat
4. Additional materials will be provided by instructor, including review articles from scientific literature.
5. Bharath Bhusan, Springer Handbook of Nanotechnology, 3rd edition, Springer-Verlag (2009)
6. CNR Rao and T. Cheetham, Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley & Sons (2005)
7. Hari Singh Nalwa, Encyclopedia of Nanotechnology, American Scientific Publishers (2004)
8. K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, 2nd edition, Elsevier (2012)
9. K. Byrappa and T. Adschiri, Hydrothermal Technology for Nanotechnology, Progress in Crystal Growth and Characterization of Materials, Volume 53 (2007) pp.117-166.
10. K. Byrappa and M. Yoshimura (Editors): Special Edition of Journal of Material Science, Volume 41, No.6 (2006).
11. K. Byrappa and T. Adschiri (Editors), Special Edition of Journal of Material Science, Volume 43, No.7 (2008).
12. Charles P. Poole Jr. and Franks J. Qwens, Introduction to Nanotechnology, Wiley & sons (2003)

12.1.5 Quantum Mechanics of Material Science (MS502)

Course Title:	Quantum Mechanics of Material Science		
Code:	MS502		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Quantum-mechanical foundation for study of nanometer-scale materials. Principles of quantum physics, operators and Dirac notation, stationary-states for one-dimensional potentials, and the hydrogen atom. Introduction to: perturbation theory, interaction with the electromagnetic radiation, angular momentum and spin, chemical bonding and molecular orbital theory, and crystalline solids and band theory.

Reference Books:

1. Quantum Mechanics for Engineering: Material Science and Applied physics by Herbert Kroemer, University of California, 1994.
2. Quantum Mechanics - L.I.Schiff
3. A text book of quantum mechanics - Mathews and venkatesan
4. Quantum mechanics – A.S. Davydov
5. Quantum Mechanics – Thankappan
6. Principles of quantum mechanics - P. A.M. Dirac
7. A text book of Quantum Mechanics: P.M.Mathews and K.Ventkatesan
8. Quantum Mechanics: Landau & Lifshitz

12.1.6 Solid State Physics for Materials Scientist (MS532)

Course Title:	Solid State Physics for Materials Scientist		
Code:	MS532		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

This course will include: Bonding in solids, Different types of crystal structures in solids, Diffraction methods in solids, Thermal properties of solids, Dielectric and optical properties of solids, Magnetic Properties of solids, Electronic and electronic properties of solids including theories and concepts on free electron model and also state Bloch's Theorem, Fermi level, Fermi function, Fermi distribution, conduction/valance band, band gap, density of states of solid state matters. All semi-empirical and approximate theory, Band theory, semiconductors, LRT, QHE, DFT, optical properties, low dimensional e-gas, theory of dispersion and lattice dynamics will be the key issue, Carbon nanotechnology, photonic crystals, molecular self-assembly, Coulomb blockade, Aharonov-Bohm effect, Anderson localization, NEMS & MEMS, photo & electroluminescence, theory of confinement, and density of states on quantum dots, wires and wells.

Reference Books:

1. C. Kittel, Introduction to Solid State Physics, Wiley, 8t h ed., (2004).
2. W. Callister & D. Rethwisch, Material Science & Engineering- Introduction, 5th Edition, Mat.Sc. & Eng, 5th Ed., Wiley (2000).
3. M. Ali Omar, Elementary Solid State Physics: Principles and applications, Addison, Wesley, (1993).

4. H. Ibach & H. Luth, Solid State Physics,3rd ed., Springer- Verlag,(2003)
5. N.W. Ashcroft & N.D. Mermin, Solid State Physics

12.1.7 Characterization and Analytical Techniques (MS535)

Course Title:	Characterization and Analytical Techniques		
Code:	MS535		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

This course covers broad range of techniques used for chemical, structural, and morphological characterization of materials. First highlight of thin films and different methods used to form film will be introduced. And then the various methods including light, and electron microscopes, and diffraction techniques such as X-ray Diffraction (XRD) technique, Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), STEM, Atomic Force Microscope (AFM), STM, X-ray photoelectron spectroscopy (XPS), Ultraviolet Photo Spectroscopy (UPS), AES, Fourier-Transform Infra-Red Spectroscopy (FTIR), RBS, Ultraviolet-visible Spectrophotometry (UV-Vis), Ellipsometry, high resolution laser spectroscopy, Z-Scan technique, and Raman techniques will be discussed.

Reference Books:

1. C. Ricbard Brundle, Charles A. Evans, Jr. and Shaun Wilson, Encyclopedia of Materials Characterization (Surfaces, Interfaces, Thin Films), 1992.
2. H. Bubert and H. Jenett, Surface and Thin Film Analysis,2002.
3. D. Myres, Surfaces, Interfaces, and Colloids: Principles and Applications, 2nd Edition, 1999.

4. Paul H. Holloway, P. N. Vaidyanathan, Characterization of Metals and Alloys, 1993.
5. Holman, Characterization of Organic Thin Films, 2010.
6. William d. Callister Jr., Fundamentals of Material Science and Engineering - An Interactive, 5th Edition, 200.
7. Kurt w. Kolasinski, Surface Science: Foundations of Catalysis and Nanoscience, 2nd Edition, 2008.
8. M. Ohring, The Material Science of Thin Film, 1992.

12.1.8 Polymer and Composite Materials (MS534)

Course Title:	Polymer and Composite Materials		
Code:	MS534		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

This course introduces the different types of Polymers and their application in electronic sector. Their properties like mechanical/thermal behavior and applications will also be addressed. The interrelationship between processing, structure, and properties will be presented with respect to the performance and design requirements of typical polymer applications. Determination of molecular weights, molecular weight distribution, crystallinity, glass transition and morphology and their effects on physical properties will be discussed. Moreover, the conducting and semiconducting polymers will be covered and emphasis will be given in this case to organic electronics. The course also covers the different types of composite materials and fibers with their properties. Processing methods of composite materials will be discussed. The course will also focus on matrix materials, used to make composites, like polymer metal and ceramic.

Reference Books:

1. Tim A. Osswald, Georg Menges, Material Science of Polymers for Engineers, Hanser Verlag, 2003.
2. David I Bower, An Introduction to Polymer physics, Cambridge University Press, May 30, 2000.
3. R.J. Young and P. A. Lovell, Introduction to Polymers, 2nd ed., Chapman & Hall, London, 1991.

4. William D. Callister, David G. Rethwisch, Material Science and Engineering: An Introduction, 8th Edition, Wiley Global Education, 2009.
5. Hagen Klauk, Organic Electronics: Materials, Manufacturing, and Applications, John Wiley & Sons, 2006.
6. Wolfgang Brütting, Chihaya Adachi, Physics of Organic Semiconductors, John Wiley & Sons, Oct 5, 2012.
7. Georges Hadziioannou, George G. Malliara, Semiconducting Polymers: Chemistry, Physics and Engineering, Wiley, 2006.
8. Terje A Skothem, and John R Reynolds, Handbook of Conducting polymers, Conjugated Polymers, Process and Application, 2nd edition, 1998.
9. http://www.orgworld.de/
10. D. D. L. Chung, Composite Materials: Science and application, Springer, New York, 2010.
11. F. L. Matthews, R. D Rawlings, Composite Materials: Engineering and Science, Oxford, CRC Press., 1999.
12. K. K. Chawla, Composite Materials: Science and Engineering, New York, Springer, 2012.
13. D. Gay, S. V. Hoa, Stephen, and W. Sai, Composite Materials: Design and Applications, Oxford, CRC Press., 2003.

12.1.9 Materials Lab-I (MS512)

Course Title:	Materials Lab-I		
Code:	MS512		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ________________________________			
Class Hours:			

The course is intended on materials characterization in relation to structural materials property like hardness, tensile strength, fatigue, viscosity, creep torsion, compressive strength, bending test and the like. The students are supposed to prepare samples that will not take significant time. The characterization instruments are mainly for use in structural materials analysis. In other words, the characterization can be for identification in mechanical property, structural (micro-structural) property and the like. Students evaluation is also based on their all experimental work, which includes their knowledge on instrumental principle, right steps/procedure and proper experimental work, analysis method and sample differentiation based on the experiment, and report writing. The course consists of the following Experiments.

1. Hardness test
2. Tensile strength test
3. Fatigue and creep test
4. Torsion and twist
5. Bending test
6. Comprehensive strength test
7. DSC (differential scanning calorimeter)
8. TGA (thermal gravimetric analysis)
9. Microstructure evolution of materials (using microscopy method/s)

Reference Books:

1. C. Ricbard Brundle, Charles A. Evans, Jr. and Shaun Wilson, Encyclopedia of Materials Characterization (Surfaces, Interfaces, Thin Films), 1992.
2. A. Turi, Thermal Characterization of Polymeric Materials (second edition), Academic Press, San Diego, CA, 1997.
3. Y. Leng. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd edition, Wiley-VCH, 2013

12.1.10 Materials Lab-II (MS613)

Course Title:	Materials Lab-II		
Code:	MS613		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____________________			
Class Hours:			

The course is intended on main materials processing and the related device application of the material, where it intends on electrical and chemical properties of materials. Furthermore, it includes the material and device characterization on the proposed experimental work. The experiments can be based on functional materials and processing conditions. Device application of the materials and specific processing conditions are also part of the lab course. Optical and electrical characterization of solar cells, nano-materials characterization, surface and interface modification using self-assembled monolayers (SAMs) for electronic applications and other nano-materials, transistor/diode characterization, sol-gel processing, solution based processing in terms of chemical and/or electrochemical, solid-state reaction, and other studies in relation to thermal/electrical/optical/magnetic properties or modification/change of different materials. The course consists of the following Experiments. Any fifteen experiments may be chosen, but the first Seven experiments should be included.

1. Solar cell characterization
2. Conductivity measurement of solid and liquid materials
3. UV-Vis characterization of materials
4. Sol-gel processing and nano-materials
5. Chromatography (gas and High-performance liquid)

6. Inductively Coupled Plasma (ICP)
7. FTIR (Fourier transform infrared spectroscopy)
8. Fourier analysis (Electronic Based)
9. Study of Monatomic and diatomic Lattices (Electrical Based)
10. Measurement of Velocity of Sound in a given liquid
11. Acousto-optic Effect
12. Faraday Effect
13. Electrical conductivity of metals and alloys with temperature-four probe method
14. Concept of communication through Optical Fiber Distance
15. Diffraction by a Single Slit using He-Ne Laser
16. Production of circularly polarized Light through Fresnel's Rhomb
17. Measurement of concentration of charge career and measurement of Hall Voltage
18. Band gap determination
19. Band gap of Germanium using Four Probe Method
20. Charge to mass ratio of Electrons by Magnetron
21. Magnetostriction Effect
22. Wavelength of He-Ne Laser using Transmission Grating
23. Wavelength of He-Ne Laser using Ruler
24. Measurement of Numerical Aperture of a multi-mode fiber
25. Holography Experiment for construction and reconstruction of a Hologram
26. Operation of Vacuum Coating Unit
27. Concept of Spatial Filtering
28. Measurement of Refractive Index of a Transparent Material through Brewster Angle using He-Ne Laser
29. Optical activity of Crystals (LiNbO3, Calcite, Quartz)
30. Study of Materials Using Electrochemical methods
31. Study of sol-gel techniques in accumulators
32. Solar cells measurements

Reference Books:

1. C. Ricbard Brundle, Charles A. Evans, Jr. and Shaun Wilson, Encyclopedia of Materials Characterization (Surfaces, Interfaces, Thin Films), 1992.
2. Schroder, Dieter K. Semiconductor Material and Device Characterization. 3rd Ed. John Wiley and Sons, Inc. Hoboken, New Jersey, 2006.
3. McGuire, Gary E. Characterization of Semiconductor Materials: Principles and Methods. Vol 1. Noyes Publications, Park Ridge, New Jersey, 1989.
4. Y. Leng. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd edition, Wiley-VCH, 2013.

12.1.11 Semiconductor Materials and Devices (MS536)

Course Title:	Semiconductor Materials and Devices		
Code:	MS536		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Microwave devices: Tunnel diode – Principle of Operation, microwave characteristics, Transfer Electronic devices, Gunn Effect Diodes, Avalanche Transistor. Time Devices: Impact Diode-Physical structure, Principle of operation, Power out & efficiency. Parametric devices- Physical structure, Non-Linear reactance, parametric amplifier & applications.

Photonic Devices: p-n junction, solar cell- Basic devices equivalent circuit, Photodetectors – Photoconductor, Photodiode, Avalanche photodiode. Light – Emitting Diodes-Radiative & Non-radiative transition, Basic processes in LEDs (Excitation mechanism, recombination of excess carries, extraction of light from semiconductor), LED Materials.

Diode Lasers: Laser action, condition for population inversion, Light confinement factor (Elementary idea). Other Electronic devices: Electro-optic, Mangento-optic & Acousto-optic Effects, Materials properties related to get these effects. Important Ferro electric, Liquid crystal & polymeric Materials for these devices, Piezoelectric, Electrostrictive & magneto strictive effects. Important Materials exhibiting these properties.

References:

1. B. Van Zeghbroeck, Principles of Semiconductor Devices, Ebook download, 2004.
2. http://www.eletrica.ufpr.br/graduacao/ebooks/Principles%20Of%20Semiconductor%20Devices.pdf
3. S. M. Sze, Semiconductor Devices: Physics and Technology, John Wiley & Sons Singapore Pte. Limited, 2013.
4. Prof. Helmut Föll's lecture (University of Kiel), Semiconductors: http://www.tf.uni-kiel.de/matwis/amat/semi_en/index.html
5. Prof. Helmut Föll's lecture (University of Kiel), Electronic Materials: http://www.tf.uni-kiel.de/matwis/amat/elmat_en/index.html
6. Peter Würfel, U. Würfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts, Wiley, 2011.
7. Wolfgang Brütting, Chihaya Adachi, Physics of Organic Semiconductors, John Wiley & Sons, Oct 5, 2012.

12.1.12 Computational Methods for Materials Scientists and Engineers (MS601)

Course Title:	Computational Methods for Materials Scientists and Engineers		
Code:	MS601		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

This course covers introduction and fundamentals in computational methods applied in modeling and simulation of Materials and devices including atomic and micro/nano scale. Special emphasis will be given to integrated modeling and simulation methods for devices like transistor, diodes, optoelectronic devices and the like. Additionally, band structure calculations in solids and a solid-state theoretical approach to the optical and electronic properties will be included. On the other hand, interactions at the atomic and/or molecular level modeling will be made, e.g., molecular dynamics simulations in Biology, Chemistry and Physics. Elementary information about Digital Computer Principles, Compilers, Interpreters and Operating system. Fortran/MATLAB/Python programming, Flow Charts, Integer and Floating Point Arithmetic, Expressions, built in functions, executable and non-executable statements, assignment, control and input-output elements, Subroutines and functions, Operation with files. Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions. Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative Method, Matrix inversion. Eigenvalues and eigenvectors of Matrices, Power and Jacobi Method. Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic Spline-fitting, Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method, random variates, Monte Carlo evaluation of Integrals, Methods of importance sampling, Random walk and Metropolis method. Introduction to molecular Dynamics. Numerical solution of ordinary differential equations, Euler and Runge Kutta method, predictor and corrector method. Elementary ideas of solutions of partial differential equations.

Reference Books:

1. W. Hergert, A. Ernst, M. Dane (Eds.), Computational Material Science, Springer-Verlag, 2004, Printed in Germany.
2. Dierk Raabe, Computational Material Science, WILEY-VCH Verlag, 1998. Germany.
3. Introduction to MATLAB-Mathworks: http://www.mathworks.com/moler/intro.pdf
4. Introduction to MATLAB for Engineering Students: http://www.mccormick.northwestern.edu/docs/efirst/matlab.pdf
5. Raj Kumar Bansal, Ashok Goel, Manoj Kumar Sharma, MATLAB and Its Applications in Engineering, Pearson Education India, 2009.
6. Marek S. Wartak, Computational Photonics: An Introduction with MATLAB, Cambridge University Press, 2013.
7. Steven T. Karris, Electronic devices and amplifier circuits with MATLAB computing, second edition, Orchard Publications, 2008.

12.1.13 Research Methods and Scientific Writing (MS691)

Course Title:	Research Methods and Scientific Writing		
Code:	MS691		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

This course covers the basics of academic/scientific writing that is helpful in writhing thesis, conference abstracts, poster, journals (letters, proceedings, and ordinary journal), books or book chapters, concept papers, and proposal. The course will deal on general formats of all these issues listed. In the course, the main issue will be on the construction of a research paper or thesis, where it includes detailed study on writing of the following: abstract, introduction, experimental/method, result, discussion, or result and discussion, conclusion or summary. The course will also be guided by exercises, writing based on a given result and topic, mainly for introduction and discussion.

Reference Books:

1. George M. Whitsides, Writing a Paper, Adv. Mat, 2004. http://www.ee.ucr.edu/~rlake/Whitesides_writing_res_paper.pdf
2. John M. Swales, Christine Feak, Academic Writing for Graduate Students, Second Edition: Essential Tasks and Skills, University of Michigan Press, 2004. http://sharif.edu/~hatef/files/Academic%20Writing%20for%20Graduate%20Students-Essential%20Tasks%20and%20Skills%20-%20For%20Nonnative%20Eng%20Speakers.pdf
3. George M. Hall, How to Write a Paper, BMJ Books, 2003.

4. Heather Silyn-Roberts, Writing for Science and Engineering: Papers, Presentations and Reports, Newnes, 2012.
5. Rebecca Gajda, Richard Tulikangas, Getting the Grant: How Educators Can Write Winning Proposals and Manage Successful Projects, ASCD, 2005.
6. Publishing Your Research 101 - Episode 1: How to Write a Paper (couples of Episode Videos): http://www.youtube.com/watch?v=q3mrRH2aS98
(Episode 1, Follow the rest).

12.1.14 Seminar on Advanced Material Science Topic (MS693)

Course Title:	Seminar on Advanced Material Science Topic		
Code:	MS693		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

A seminar that can be a basis for the thesis work or a stepping stone to the senior project is offered.

12.1.15 Graduate Project in Material Science (MS694)

Course Title:	Graduate Project in Material Science		
Code:	MS694		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ______________________________			
Class Hours:			

Based on the advanced topics in Material Science preferably an experimental topic is chosen for graduate project with submission of a report paper that should be openly defended and evaluated. This course give students an opportunity to develop and demonstrate their ability to carry out and document a reasonably comprehensive project requiring considerable initiative, creative thought, and a good deal of individual responsibility.

Students can choose their final project advisor from the staff depending on the staff member's research work and expertise. The main advisor of student's paper can select internal and external advisor and get approved by the department. The duration of the thesis work depends on the type of project, availability of the instrument and chemical and other factors, but it is generally assumed to take two semesters. Research collaboration can also be made with domestic industries, other governmental and non-governmental offices, universities and the like. It's the student's job to run the whole experiment and write his/her entire paper work. If the student wants to publish on a journal, he/she should report to their advisor and should get a permission to do so.

12.1.16 Master Thesis in Material Science (MS696)

Course Title:	Master Thesis in Material Science		
Code:	MS696		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Based on the advanced topics in Material Science preferably an experimental topic is chosen for research with submission of a dissertation that should be openly defended and evaluated. The thesis gives students an opportunity to develop and demonstrate their ability to carry out and document a reasonably comprehensive project requiring considerable initiative, creative thought, and a good deal of individual responsibility. The thesis may be a design project, an analytical paper, or experimental work of a technical nature.

Students can choose their final thesis advisor from the staff depending on the staff member's research work and expertise. The main advisor of student's thesis can select internal and external advisor and get approved by the department. The duration of the thesis work depends on the type of project, availability of the instrument and chemical and other factors, but it is generally assumed to take two semesters. Research collaboration can also be made with domestic industries, other governmental and non-governmental offices, universities and the like. Students should also be able to show their original and independent research work while the advisor is guiding their research work. It's the student's job to run the whole experiment and write his/her entire research work. If the student wants to publish on a journal, he/she should report to their advisor and should get a permission to do so.

12.2 Elective Courses-I

12.2.1 Materials Preparation Techniques (MS681)

Course Title:	Materials Preparation Techniques		
Code:	MS681		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Solid state routes; Nucleation; Role of impurities; Mechanical mixing; Grinding; Solid solution techniques. Top-Down reactions. Rate of crystallization. High temperature processes – heating, annealing, sintering treatment; Sputtering, Spin Coating. Evaporation; precipitation; Solution growth; Nucleation; Rate of crystallization; Superstaturation; Top seeded solution growth; sol-gel techniques; high temperature solution; Hydrothermal; Solvothermal methods; Ammonothermal method; Glycothermal; Melt methods, super cooling, Czechorlskii methods; Skull melting. Vapour phase methods - Thin films, epitaxial growth, substrates selection, career gases, metastable growth of materials. Chemical Vapor Deposition - Principles, apparatus, examples of CVD growth of thin films, advantages and disadvantages; Chemical Vapor Transportation; Molecular Beam Epitaxy, Liquid Phase Epitaxy, Vapor growth of Nitrides. Metal-organic Vapor phase epitaxy. Plasma Energetics; Laser ablation. Biological synthesis, Biomimetic method, bacterial synthesis of nanoparticles; Electrochemistry - solvent selection, apparatus, deposition, growth of thin films, coatings, examples; Multi-energy processing – Mechanochemical; Sonochemical; Photochemical; Biochemical, Microbial, Organic synthesis. Growth of organic crystals.

Reference Books:

1. Springer Handbook of Crystal Growth; Eds: G. Dhanraj, K. Byrappa, V. Prasad, M. Dudley, Springer Verlag (2010)
2. Springer Handbook of Nanotechnology; Eds: Bharath Bhushan, Springer Verlag, 2nd Edition (2009).
3. Handbook of Crystal Growth, K. Byrappa and T. Ohachi, Springer-Verlag (2003).
4. Growth of Single Crystals, R.A. Laudise, Prentice-Hall (1973).
5. Growth and Characterization of Technologically Important Crystals, By: K. Byrappa, R. Fornari, T. Ohachi, H. Klapper, Allied Sciences, New Delhi (2003).

12.2.2 Spectroscopic Techniques for Materials (MS683)

Course Title:	Spectroscopic Techniques for Materials		
Code:	MS683		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

UV-Visible & Raman Spectroscopy: Spectrum of Electromagnetic Radiation, UV-Visible Spectroscopy of Materials; Principle of working, instrumentation, experimentation, analysis of the UV-Vis spectrum, FITR Spectroscopy- Principle of working, instrumentation, experimentation, analysis of the FTIR spectrum, Brief Theory of Raman Spectroscopy-Instrumentation-Sample Handling and spectrum recording, Diagnostic Structural Analysis-Polarization Measurements-Quantitative Analysis, Nuclear Magnetic Resonance Spectroscopy, Basic Principles of NMRS - Continuous Wave NMR Spectrometers - Principle of working, instrumentation, experimentation, analysis of the NMR spectrum, Pulsed Fourier Transform NMR Spectrometer - Principle of working, instrumentation, experimentation, analysis of the NMR spectrum; Molecular Structure - Quantitative Analysis from the NMR spectroscopy. Electron Spin Resonance Spectroscopy; its behavior in materials-ESR Spectrometer - Principle of working, instrumentation, experimentation, analysis of the ESR Spectra - Interpretation of ESR Spectra for the determination of properties of the materials- Quantitative Analysis, Mass Spectrometry, Ion Scattering Spectrometry: Brief theory, Principle of working Instrumentation and data acquisition and analysis; Secondary Ion Mass Spectrometry (SIMS) - Brief theory, Principle of working, Instrumentation and data acquisition and analysis, Auger Emission Spectroscopy (AES) - Brief theory, Principle of working, Instrumentation and data acquisition and analysis, Electron Spectroscopy for Chemical Analysis (ESCA)- Brief theory, Principle of working, Instrumentation and data acquisition and analysis, Low Energy Electron Diffraction (LEED) - Brief theory, working Principle, Instrumentation and data acquisition and analysis, Photoelectron Spectroscopy (PES) Brief theory, Principle of working, Instrumentation and data acquisition and analysis.

Reference Books:

1. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBS publishers & Distributors, Delhi, Sixth Edition, 1986.
2. Colin N. Barnwell and Elaine M. McCash, Molecular Spectroscopy, McGraw-Hill College; 4 Sub edition (June 1, 1994), ISBN-10: 0077079760

12.2.3 Introduction to Micro and Nano Fabrication (MS661)

Course Title:	Introduction to Micro and Nano Fabrication		
Code:	MS661		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

The course aims to introduce to students the basic technologies and knowledge of nano/microfabrication, and give them hands-on experiences in making nano/microstructures and handling sophisticated equipment. The course consists of four one-hour lectures (one per week), seven three-hour labs (one lab per week), and three experiments. Each student begins with a bare silicon wafer and ends with micro-structures consisting of resistors, capacitors, diodes, and transistors. Students learn and perform wafer cleaning, thermal oxidation of thin films, dopant diffusion, photolithography, chemical etching, metal thin-film evaporation, and related characterization methods. It also deals with aspects of the technology of processing procedures involved in the fabrication of microelectronic devices and microelectromechanical systems (MEMS). Students will become familiar with various fabrication techniques used for discrete devices as well as large-scale integrated thin-film circuits. Students will also learn that MEMS are sensors and actuators that are designed using different areas of engineering disciplines and they are constructed using a micro-lithographically-based manufacturing process in conjunction with both semiconductor and micromachining microfabrication technologies.

Reference Book:

- Introduction to Microfabrication, 2nd Edition by Sami Franssila, 2010.

12.2.4 Science and Technology of Thin Films and Nanomaterials (MS663)

Course Title:	Science and Technology of Thin Films and Nanomaterials		
Code:	MS663		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ______________________________			
Class Hours:			

The course is designed for the students to be familiar with: 1) Vacuum science and technology (kinetic gas theory, application, vacuum pumps and measurement), thin film growth techniques (evaporation and sputtering), 2) microstructure/property relationships in thin films, 3) substrate surface and nucleation (thermodynamics and kinetics of nucleation and growth), epitaxy (lattice misfit and defects, mechanisms and characterization), 4) film structure (structural morphology, grain growth, texture, microstructure control and amorphous thin films), mechanical properties of thin films (internal stresses: origin and analysis, mechanical relaxation effects)

Reference Books:

1. M. Ohring, The Material Science of Thin Films, Academic Press (1992 first edition, 2002 second edition)
2. D.L. Smith, Thin- Film Deposition, McGraw- Hill, Inc., 1995.
3. K.N. Tu et al. Electronic Thin Film Science, Macmillan, 1992.
4. R.C. O'Handley, Modern Magnetic Materials, Wiley, 2000.
5. H. L. Tuller, Nanostructured Materials: Selected Synthesis Methods, Properties and Applications, Kluwer Academic Publishers, 2002.
6. R. W. Kelsall, I. W. Hamley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons Ltd., 2005.

7. W. A. Goddard, D. W. Brenner, S. E. Lyshevski, G. J. Iafrate, Handbook Of Nanoscience, Engineering, and Technology, CRC Press LLC, 2003.

12.2.5 Biomaterials (MS671)

Course Title:	Biomaterials		
Code:	MS671		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ______________________________			
Class Hours:			

An introduction to materials in medicine, properties of materials for medicine, classes of materials used in medicine, The role of adsorbed proteins in tissue response to biomaterials, host reactions to biomaterials and their evaluation, biological testing of biomaterials, degradation of materials in the biological environment, production of biomaterials, application of materials in medicine, biology, and artificial organs, tissue engineering, implants, devices, and biomaterials: Issues unique to this field, perspectives and possibilities in bioMaterial Science.

Relationships between material properties, suitability to task, surface chemistry, processing and treatment methods, and biocompatibility. Properties, processing and usage of biocompatible materials.

Reference Books:

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, BioMaterial Science: An Introduction to Materials in Medicine, 2nd Edition, 2004
2. Marcel De Cuyper and Jeff W.M. Bulte, Physics and Chemistry basis of Biotechnology, Kluwer academic publishers, 2001

12.2.6 Carbon Nanotubes (MS665)

Course Title:	Carbon Nanotubes		
Code:	MS665		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

From a Graphene Sheet to a Nanotube - Archiral and Chiral Nanotubes – Single wall, Multiwall and Bundled Nanotubes - ZigZag and Armchair Nanotubes - Eulers Theorem in Cylindrical and Defective Nanotubes, Production Techniques of Nanotubes. Carbon Arc Bulk Synthesis in Presence and Absence of Catalysts - High - Purity Material (Bucky Paper) Production Using Pulsed Laser Vaporization (PLV) of Pure and Doped Graphite - High- Pressure CO Conversion (HIPCO) - Nanotube Synthesis Based on Boudoir Reaction-Chemical Vapor Deposition (CVD) - Synthesis of Aligned Nanotube Films. Growth of Single-Wall / Multiwall Nanotubes, Experimental Puzzles of SWNT - High Yield - Universality of Diameter - Role of Metal Catalyst - Application of Continuum Elasticity Theory to Nanotubes - Tube Diameter Optimization in a Finite System-Continuous Growth by Addition of Carbon at the Open Edge-Role of Metal Catalyst - Termination of Growth. Experimental Puzzles of MWNT – Aspect Ratio-Perfection-chemical inertness - Independent or Concerted Growth Equilibrium Structure of Double – Wall Nanotubes-Structure Stability at The Growing Edge-Termination by a Multi - Walled Dome. Structural, Electronic Properties & Applications of Nanotubes Structural Changes in Free - Standing and Interacting Nanotubes Liberations, Rotations - Effect of Inter tube interactions on the Electronic Structure Electronic Structure of Graphite as Building Block of Nanotubes. Effect of Chirality and Discrete Atoms- Conducting versus Insulating Nanotubes - Band Structure of Metallic Carbon Nanotubes - Effect of Doping on conductivity -

Harnessing Field Enhancement- Flat Panel Displays - Carbon nanotubes & Drug Delivery.

Reference Books:

1. M.Endo, S.Iijima, M.S. Dresselhaus, Carbon Nanotubes, Pergamon; Ist Ed Edition (December 1st 1996), ISBN-10: 0080426824
2. AdoJorio, Mildred S. Dresselhaus, and Gene Dresselhaus Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Springer; 1st edition (April 20,2001) ISBN-10: 3540410864

12.2.7 Ceramics Science and Technology (MS673)

Course Title:	Ceramics Science and Technology		
Code:	MS673		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Definition & scope of ceramics and ceramic materials. Examples of ceramic crystals, short-range and long-range order, imperfections, polymorphism. Ceramic Binary and ternary systems, ceramic microstructures. Crystallization of glass and glass-ceramics. Thermal, electrical, magnetic and optical properties of ceramics and application. Classification of ceramic materials conventional and advanced, Areas of applications. Conventional Ceramics: b) Refractories: Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application. c) White-wares: Classification and type of White-wares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas. d) Ceramic Coatings: Types of glazes and enamels, Elementary ideas on compositions, Process of enameling & glazing and their properties. e) Glass: Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses. Application of glasses. f) Cement & Concrete: Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC. Compound formation, setting and hardening. Tests of cement and concrete. Elementary ideas about the raw materials used in pottery, Heavy claywares, Refractories, Glass, Cement, Industries. Raw materials clays and their classification, Quartz, Polymorphism of quartz, Feldspar and its classification, Talc, Steatite and Mica. Fabrication methods: Packing of Powders, Classification and scope of various fabrication methods. Dry and semi dry pressing. extrusion, Jiggering & jollying, Slip casting HP & HIP. Drying & Firing of ceramics: Biscuit firing and glost firing, fast firing technology, action of heat on triaxial body, Elementary ideas of various furnaces used is ceramic industries. Advanced ceramics: Bio-ceramics, Space ceramics, Automotive ceramics, Electronic ceramics, Superconducting ceramics, Elementary ideas of their preparation and applications.

Reference Books:

1. F.H Norton, Elements of Ceramics, Addison-Wesley Press (1974)
2. M.W. Barsoum, Fundamentals of Ceramics, McGraw-Hill (2003)
3. W.D Kingery, Introduction to Ceramics, Wiley & Sons (1976).
4. Lawrence H. Van Vlack, Physical Ceramics for Engineers, Addison-Wesley Publishing (1964).
5. F. Singer and S.J. Singer, Industrial Ceramics, Chapman & Hall, UK (1963)

12.2.8 Materials for Renewable Energy and Storage (MS675)

Course Title:	Materials for Renewable Energy and Storage		
Code:	MS675		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ______________________			
Class Hours:			

Introduction to new generation of materials and nano-engineering of their structures for sustainable energy economy. Contribution to high performance renewable energy production, storage, conversion and usage. Solar grade glass; (a) properties- transparency, emissivity and reflectivity, (b) manufacturing- Flat glass for PV & CSP, tube glass for Evacuated Tube Receiver (ETR) and Collector (ETC). Solar Photo Voltaic (PV) cells: Single and multi-crystalline silicon solar cells, amorphous silicon, thin film; Cd-Te, CIGS, CZTS, nano-, micro-, Poly-Si. Transparent conducting coating, Multi-junction, solar PV concentrator, flexible solar cells, Emerging PV; dye sensitized, other organic, and quantum dot cells. Nano-engineered materials. Materials for Concentrated Solar Power (CSP): Reflector materials; glass, metal, polymer and film. Receiver and collectors; absorptive coating and anti-reflective coating. Materials and shapes for thermal storage, Lithium ion Batteries. Fuel cells; materials and construction; PEM Fuel Cell(FC), AFC, PAFC, MCFC, SOFC. Catalysts for electro catalysis, fuel reformer and water splitting.

Reference Books:

1. Vielstich, W., et al. (eds.) (2009). Handbook of fuel cells: advances in electro-catalysis, materials, diagnostics and durability. 6th vol. Hoboken: Wiley, 2009

2. Francis de Winter, Solar Collectors, Energy Storage, and Materials (Solar Heat Technologies), MIT Press, USA (1991)
3. David S. Ginley, David Cahen, Fundamentals of Materials for Energy and Environmental Sustainability, Cambridge University Press (2011)
4. Materials, Electronics, and Renewable Energy Part III Physics, Small lecture theatre, Cavendish Laboratory lecturers: David MacKay and Neil Greenham
5. Fuel Cell Handbook,
6. Introduction to Fuel Cell Technology

12.2.9 Graphene Physics (MS667)

Course Title:	Graphene Physics		
Code:	MS667		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

From a recommended nomenclature for two-dimensional carbon materials to Synthesis, Characterization, and Selected Properties of Graphene, Understanding Graphene via Raman Scattering, Physics of Quanta and Quantum Fields in Graphene, Magnetism of Nanographene, Physics of Electrical Noise in Graphene, Suspended Graphene Devices for Nanoelectromechanics and for the Study of Quantum Hall Effect, a Detailed Computational Study Electronic and Magnetic Properties of Patterned Nanoribbons, Stone–Wales Defects in Graphene and Related Two-Dimensional Nanomaterials, Graphene and Graphene-Oxide-Based Materials for Electrochemical Energy Systems, Heterogeneous Catalysis by Metal Nanoparticles Supported on Graphene, Graphenes in Supramolecular Gels and in Biological Systems, Biomedical Applications of Graphene: Opportunities and Challenges,

Reference Books:

1. C. N. R. Rao and A. K. Sood, Graphene: Synthesis, Properties and Phenomena, Wiley-VCH Verlag & Co. KGaA, 2013
2. Mikhail I. Katsnelson, Graphene: Carbon in Two Dimensions, Radboud University, the Netherlands, Cambridge University Press, 2012
3. M.Endo, S.Iijima, M.S. Dresselhaus, Carbon Nanotubes, Pergamon; Ist Ed Edition (December 1st 1996), ISBN-10: 0080426824

4. James E. Morris, Kris Iniewski, Graphene, Carbon Nanotubes, and Nanostructures: Techniques and applications; CRC Press (Taylor & Francis Group)

12.3 Elective Courses-II

12.3.1 Physics and Chemistry of Polymers (MS672)

Course Title:	Physics and Chemistry of Polymers		
Code:	MS672		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Basic concepts: Classification of polymers, Nomenclature of Polymers concepts such as monomer, polymer, oligomer, dendrimer; functionality and physical state (amorphous and crystalline) Stereo-regular polymers, co-polymers, block and graft co-polymers, molecular forces and chemical bonding in polymers. Polymerization mechanism, addition and condensation including co-ordination, cationic, anionic, Ring opening Redox polymerization, Living Radical Polymerization-Atom transfer radical polymerization. Methods of Polymerization – Bulk, solution, precipitation polymerization, Suspensions, emulsion, melt poly-condensation, interfacial polymerization, solution. poly-condensation, solid phase, gas phase and (formulation, mechanism, properties of the polymer produced advantages and disadvantages of each technique). Criteria of polymer solubility, solubility parameter, thermodynamics and phase equilibria of polymer solution, Fractionation of polymers by solubility. Structure property relationship in polymers, configuration of polymer chains, crystallinity in polymers, crystallization and melting, strain induced morphology, crystalline melting point, glass transition temperature, factors influencing Tg and Tm. Polymer rheology: Viscous flow, Kinetic theory of rubber elasticity, Visco-elasticity, Molecular weight and size: Importance of molecular weight, Molecular weight distribution, concept of Average molecular weights, measurement of molecular weight by end group analysis, colligative property, Light scattering, Ultracentrifugation, dilute solution viscosity, Gel permeating chromatography.

Reference Books:

1. Text book of Polymer Science – Fred W. Billmeyer, J.R. John Wiley & Son, New York. (1990)
2. Polymer Science – V.R. Gowarikar, N.V. Vishwanathan, Jayadev Shreedhar Wiley Eastern Ltd. New Dehli, India (1986)
3. Analysis of polymers – an introduction – T.R. Crompton. Smithers Rapra Technology Pvt Ltd., SY4 4NR, UK, 2008
4. Experimental methods in polymer chemistry – J.F. Rabek. John Wiley and Sons NY (1980)
5. Polymer Science, P.L. Nayak, Kalyani publishers, New Dehli.(2005)
6. Analysis and Characterization of Polymers – Sukumar Maiti, Ansandhan Prakashan, Midnapur, India. (1978)

12.3.2 Analytical and Inorganic Chemistry (MS642)

Course Title:	Analytical and Inorganic Chemistry		
Code:	MS642		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Statistical Treatment of Analytical Data: Limitations of analytical methods. Classification of errors: - Systematic errors- Sources, effects and their reduction. Random errors - Sources and distribution. Accuracy and precision. Fundamentals of chromatography: General description- Definition, terms and parameters used in chromatography (RF- value, retention volume and time). Ion-exchange chromatography (ICH), The synthesis of novel cation (Amberlite TR-1204) and anion exchange resin materials and its application in ion exchange chromatographic separation of the components from the reaction mixture. Potentiometry and conductometry: Theory, principle of working and few applications. Ionic bond and covalent bond: Properties of ionic substances, structure of ionic crystals, Hybridization, VSEPR concept to explaining the structure of simple molecules of materials. Application of physical chemistry- Application of phase rule to two and three component systems. Concepts of entropy and free energy. Partial molar volume and its determination by density measurements. Symmetry elements and symmetry operations with examples of simple molecule materials. X-ray diffraction, Bragg equation and Miller indices. Order of a reaction and its determination. Energy of activation and its determination. Assumption of activated complex theory. Fast reactions with examples, polymers and their classification. Arrhenius theory of strong and weak electrolytes. Corrosion and its prevention. Law of photochemistry. Quantum yield and its determination. Photo degradation of materials, Photo catalyst- ZnO, TiO2, principle of photo catalyst, application of ZnO, TiO2 in the photo degradation of various types, pesticides and in industrial effluents. Effect of photo degradation on chemical oxygen demand in drinking water and in industrial waste water. Photo physical properties of materials; Theory, instrumentation, and applications of fluorescence, characteristic of fluorescence, resonance fluorescence, sensitized fluorescence, quenching of fluorescence. Theory, principle, and applications of phosphorescence. Organic Chemistry- Importance of natural products and synthetic products of organic origin materials in industry, pharmaceutical, petroleum refinery and agricultural fields. Uses of Dyes, polymers (plastics) soaps and detergents in industry, drugs and cosmetics in pharmaceutical industries, waxes, coal tar from petroleum industry and pesticides, (insecticides, pesticides, herbicides, fumigacide etc.)

Reference Books:

1. Quantitative analysis. R. A. DAY and A. L. Underwood 6th edition Prentice Hall, Inc1999
2. Principle of Instrumental analysis, D.A.skoog, F.J.Holler and T.A.Nieman, 5thedition. Thomson Asia pvt.Ltd. Singapore 1998
3. Analytical chemistry. G.D. Christian 5th edition 2001, John-Wiley and sons Inc. India
4. Chemical kinetics. KJ. Laidler
5. Chemical kinetics. Moore and Pearson
6. Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.
7. Advances in Photochemistry - Rohatgi Mukherjee
8. Principle and applications of Photochemistry – R.P. Wayne, Elsevier, New York, (1970).
9. Elements of physical chemistry – Glass stone and lewis
10. Encyclopedia of chemical technology – Kirck-othmer series

11. Inorganic chemistry – JE Huheey
12. Chemical Kinetics –L.K. Jain.
13. Physical chemistry by PW. Atkins, ELBS, 4th edition, Oxford University press (1990).

12.3.3 Physical Chemistry (MS644)

Course Title:	Physical Chemistry		
Code:	MS644		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ______________________________			
Class Hours:			

Electrochemistry: Electrolytic conductance - Debye- Huckel theory of Interionic attraction, Debye-Huckel limiting law, energetic of electrochemical reactions, electrode potential and EMF application of EMF measurements, potentiometric titrations.

Electrochemical devices: Galvanic cells (primary and secondary), concentration cells and fuel cells, polarization, over voltage, decomposition potential and electrodeposition techniques.

Corrosion: introduction and importance of corrosion studies, theories of corrosion, factors influencing corrosion, forms of corrosion, corrosion control measures, through paints, metal coatings, anodic and cathodic protection polarization studies, corrosion rate measurement, Tafel extraploration passivity, analysis of corrosion failure.

Chemical Thermodynamics: Brief resume of concepts of laws of thermodynamics. Free energy, chemical potential and entropy. Gibb's-Helmholtz equation and Maxwell's relation. Real Gases: Definition of fugacity, standard state of real gases. The relation between fugacity and pressure. Concept of activity and activity coefficient and their determination by vapor pressure methods. Non-ideal behavior: partial molar quantities, partial moral volume ant its determination by dilatometry. Partial molar entropy and its determination by calorimetry.

Chemical Dynamics-I: A brief review of basic concepts and terminology in reaction kinetics. Methods of determining rate laws. Arrhenius equation. Collision state theory for bimolecular reaction rates. Transition state theory. Comparison between collision and transition state theories. Lindeman and RRKM theories of unimolecular reaction rates. Concepts and significance of energy of activation. Dynamics in solution: Ionic reactions, effect of ionic strength. Primary and secondary salt effects. Numerical examples. Dynamics of chain reaction: general aspects of chain reactions, parallel and complex reactions, consecutive and opposite reactions.

Colloids, surfactants and interfacial phenomenon: Introduction to Colloids and Surfactants. Determination of Critical Micellar concentration from surface tension measurements.

Reference Books:

1. Chemical Kinetics and Dynamics, J.I. Stiefield, J.S. Franciso and W.L. Hase, Prantice Hall, Eaglewood Cliffs, New Jersy, 1989.
2. The surface chemistry of solids, S.J.Gregg Chappman and Hall Ltd, 1961.
3. Introduction to kinetics of chemical chain reactions, Gimblett, TMH.
4. Chemical Kinetics, Laidler.
5. Problems in Physical Chemisty, K. K. Sharma, Vikas Pub. House, New Delhi, 2000
6. Physical Chemistry by P.W. Atkins, 1980.

12.3.4 Semiconductor Optoelectronics (MS652)

Course Title:	Semiconductor Optoelectronics		
Code:	MS652		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____			
Class Hours:			

Review of Semiconductor Device Physics: Energy bands on solids, the E-k diagram, Density of states, Occupation probability, Fermi level and quasi Fermi levels, p-n junctions, Schottky-junction and Ohmic-contacts. Semiconductor optoelectronic materials, Bandgap modification, Hetero-structures and Quantum Wells. Interaction of photons with electrons and holes in a semiconductor: Rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier. Semiconductor Optical Amplifiers & Modulators: Semiconductor optical amplifiers (SOA), SOA characteristics and some applications, Quantum-confined Stark Effect and Electro-Absorption Modulators. Semiconductor Photon Sources: Electroluminescence. The LED: Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory and device characteristics; direct modulation. Quantum-well laser; DFB-, DBR- and vertical-cavity surface-emitting lasers (VCSEL); Laser diode arrays. Device packages and handling. Semiconductor Photodetectors: Types of photodetectors, Photoconductors, Single junction under illumination: photon and carrier-loss mechanisms, Nosie in photo-detection; Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance. Photo-transistors, solar cells, and CCDs. Optoelectronic integrated circuits – OEICs.

Reference Books:

1. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007), Ch.16, 17, and 18.
2. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
3. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995)
4. G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3rd Ed. (2000), Ch.4,6.
5. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007), 6th Ed. Ch.15-17.
6. J. M. Senior, Optical Fiber Communication: Principles and Practice, Prentice Hall of India, 2nd Ed. (1994), Ch.6-8.

12.3.5 Nano-biotechnology in Health Care (MS662)

<table>
<tr><td>Course Title:</td><td colspan="3">Nano-biotechnology in Health Care</td></tr>
<tr><td>Code:</td><td colspan="3">MS662</td></tr>
<tr><td>Credits</td><td colspan="3">3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)</td></tr>
<tr><td>Prerequisite(s):</td><td></td><td>Co-requisite(s):</td><td></td></tr>
<tr><td>Academic Year:</td><td>20_____</td><td>Semester:</td><td>I ☐ / II ☐</td></tr>
<tr><td>Program:</td><td>Graduate</td><td>Enrollment:</td><td>Regular</td></tr>
<tr><td colspan="4">Instructor's Name: ____</td></tr>
<tr><td>Class Hours:</td><td colspan="3"></td></tr>
</table>

Introduction on biocompatible nano-particles (Gold, silver, zinc, carbon, graphene and quantum dots), synthesis and applications. Nanobiosensors and Lab-on-chip devices for ultrasensitive diagnostics: Amperometric, potentiometric and potentiometric and flurometric biosensors (glucose biosensors, enzyme biosensors, screen printed electrodes); Affordable diagnostics. Techniques involved in Nanoparticles application in diagnostics and characterization: Fluorescence resonance energy transfer (FRET), Surface energy transfer (SET), Raman light scattering, Surface Plasmon Resonance (SPR), Transmission electron microscopy, Scanning electron microscopy, Atomic force microscopy, Confocal microscopy, Scanning tunneling microscopy, Fluorescence spectroscopy. Micro-array (DNA and Protein array)-concepts and advantages of Microfluidic devices, Materials for manufacture of microfluidic devices (Silicon and PDMS). Nanoparticles for Optical Imaging of Cancer, Nanogold in Cancer Therapy and Diagnosis, Nanotubes, Nanowires, Nanocantilevers and Nanorods in Cancer Treatment and Diagnosis. Carbon Nanotubes in Cancer Therapy and Diagnosis. Liposomes, dendrimers, Layer by layer deposition, self-assembled monolayers, In-vivo imaging. Nanobiotechnology for food health and environment.

Reference Books:

1. From Bioimaging to Bisensors – Noble Metal Nanoparticles in Biodetection, by Lai-kwan Chau (National Chung Cheng University, Taiwan), Huan-Tsung Chang (National Taiwan University, Taiwan)
2. Advances in Biosensors, Volume 1, Volume 1, Reinhard Renneberg and A.P.F. Tuner, 1991.
3. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-Based Biosensing for Monitoring Food Toxins and Pesticides, M. S. Thakur, Rajeev Ranjan, Aaydha C. Vinayaka, Kunhitlu S. Abhijith, and Richa Sharma. Advanes in Applied Nanotechnology for Agriculture, Chapter 4, 2013, pp 55-84, ACS Symposium Series, Volume 1143.
4. Nanomaterials for Cancer Diagnosis, Challa S. S. R. Kumar (Editor), ISBN: 978-3-527-31387-7,448 pages, January 2007.
5. Microarray Technology and Its Applications, Uwe R. Muller, Dan V. Nicolau, Springer, 30-Mar-2006- Technology and Engineering.
6. Nanoparticulates as Drug Carriers edited by Vladimir P Torchilin (Northeastern University, USA), 2006, Imperial college press.

12.3.6 Nano-photonics (MS664)

Course Title:	Nano-photonics		
Code:	MS664		
Credits	3 Cr. hrs. ≡ Lecture: (3 hrs.) + Tutorial: (1 hrs)		
Prerequisite(s):		Co-requisite(s):	
Academic Year:	20_____	Semester:	I ☐ / II ☐
Program:	Graduate	Enrollment:	Regular
Instructor's Name: ____________________			
Class Hours:			

Quantum confined materials: Quantum dots - Optical transitions absorption - interband transitions - quantum confinement - intraband transitions, fluorescence/luminescence - photoluminescence/fluorescence optically excited emission electroluminescence emission. Plasmonics: Internal reflection and evanescent waves - plasmons and surface plasmon resonance - Attenuated Total reflection - Grating SPR Soupling - Optical Waveguide SPR coupling - SPR dependencies and materials - plasmonics and nanoparticles. New Approaches in Nanophotonics: Near filed optics - Aperture less near field optics - near field scanning optical miroscopy (NSOM or SNOM) - SNOM based detection of plasmonic energy transport - SNOM based visualization of waveguide structures - SNOM in nanolithography - SNOM based optical data storage and recovery. Biophotonics: Interaction of light with cells-tissues - nonlinear optical processes with intense laser beams - photo induced effects in biological systems - generation of optical forces - optical trapping and manipulation of single molecules and cells in optical confinement- laser trapping and dissection for biological systems-single molecules biophysics - DNA protein interaction.

Reference Books:

1. H Masuhara, S Kawata and F Tokunga, Nanobiophotonics, Elsevier Science 2007.

2. BEA Sale and A C Teich, Fundamentals of photonics, John Wiley and Sons, NewYork 1993.
3. M Ohtsu, K Kobayashi, T Kawazoe and T Yatsui, Principals of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan (2003).
4. P N Prasad, Introduction to Biophotonics, JohnWiley and Sons (2003).

13. Teaching Staff and Assistants

The teaching staff for the program will be expected to comprise the following members:

1. Dr. Abebe Tedla: Assistant Professor (PhD in Polymer Chemistry)
2. Dr. Mequanint Assefa: Assistant Professor (PhD in Solid State Physics)
3. Mr. Gizaw Birhanu: PhD Candidate in Material Science
4. Mr. Asratemedhn Bekele: PhD Candidate in Material Science
5. Mr. Asfaw Negash: PhD Candidate in Nano Science
6. Mr. Newaye Belachew: PhD Candidate in Nano Science
7. Mr. Bizuneh Bekele: PhD Candidate in Polymer Physics (will complete next year)
8. Mrs. Newayemedhn Abera: PhD Candidate in Polymer Physics (will complete next year)
9. Mr. Abel Tesfaye: Lecturer (M.Sc. in Computational Physics)
10. Other Expatriate Professors

14. Labs, Facilities and Equipment Required

- **Optical Spectroscopic Facility: -** UV-Vis Absorption, micro-Raman (visible, NIR excitation), FTIR, Photo-Luminescence (PL), Photo-Luminescence Excitation (PLE), Ellipsometry.
- **Microscopy facility:** - SEM, TEM, AFM
- **Carbon Nanoscience Facility: -** Ultra-High-Vacuum CVD/Molecular-Deposition tool
- **Glass Processing and Characterization Facility: -** Modulated Differential Scanning Calorimeter, Differential Scanning Calorimeter
- **Polymer Synthesis and Processing Laboratory: -** Facilities to synthesize, process and fabricate polymer based systems & devices.
- **Thin Film Deposition Facility: -** Dual-source RF-magnetron sputtering deposition system
- **Materials Processing and Characterization: -** Chemical Synthesis Facilities (Porosimeter)
- **Surface Chemistry and Electrochemistry Laboratory: -** Cyclic Voltammetry, Megbowl process system

- **High Temperature Ceramic Processing Laboratory: -** High Temperature Furnaces (Spark plasma sintering (SPS) furnace, High-temperature tube furnace-controlled ramp rate up to 1100 °C, Glass melting furnaces-standard box furnace operated up to 800°C)
- **Computational Material Science and Engineering Laboratory**
    - Abinitio quantum chemical simulation (VASP, Path-Integral Molecular Dynamics code),
    - atomistic simulation tools (Molecular dynamics and Monte Carlo simulators),
    - Finite Element,
    - Finite Difference Time Domain simulators,
    - multiscale-multiphysics suite of codes.
    - Virtual NanoLab (VNL)

15. Quality Assurance Measures

Quality assurance is considered as the most important component of the teaching-learning process in the Department. The program uses the following mechanisms to assure the quality of the teaching – learning process:

- Preparation of standard course Guide book as per the course description;
- Recruiting and maintaining higher professional instructors/professors;
- Providing standard textbooks for each course as per the library standard;
- Maintaining appropriate student/instructor ratio;
- Monitoring performance against program objectives;
- Evaluation of student performance through published criteria, regulations, and procedures that are applied consistently;
- Ensuring the availability of learning resources and student support;
- Involving of students in the teaching learning process;
- Ensuring that teaching-learning is integrated with practical experience;
- Conducting regular feedback assessment from employers and employed alumni;

- Conducting regular course self-evaluation, program self-evaluation and program peer and external evaluation; etc.
- Strictly following the guidelines set by Academic Standards and Quality Audit Committee (ASQAC)

Bibliography

1. M. Sayer and A. Mansingh, "*Measurement, instrumentation and experiment design in physics and engineering"*, Prentice-Hall India Pvt.Ltd., New Delhi, 2000.
2. H.S. Kalsi, '*Electronic instrumentation*', (2nd Edition), Tata McGraw Hill Publ.Co.Ltd., New Delhi, 2004.
3. R.F. Coughlin and F.F. Driscoll, "*Operational amplifiers and linear integrated circuits*", Pearson Education, New Delhi, 2001.
4. E.O. Doebelin, "*Measurement systems: Applications and Design*", McGraw-Hill, New York, 2002.Rangan Sharma and Mani, "*Instrumentation devices and systems*", Tata McGraw-Hill, New Delhi, 2000.
5. *Harmonized curriculum for Master of Science (M.Sc.) in Physics*. July 2012. Ministry of education, Addis Ababa.
6. *Modular M.Sc. program in Physics*, November 2009, Department of Physics, Addis Ababa University.
7. *M.Sc. Program in Nuclear Physics*, April 2014, Department of Physics, Debre Berhan University.
8. Hawassa University, Faculty of Natural Sciences, *MSc Curricula for: (1) MSc in Physics (Material Science) and (2) MSc in Physics (Thin Film Technology)*
9. *Applied Solid State Physics Curriculum*: Physics, August, 2014, Faculty of Science and Humanities, M S Ramaiah University of Applied Sciences - Bangalore, India.
10. Tuskegee University, College of Engineering, *Master of Science (MS) in Material Science and Engineering*
11. http://www.nap.edu/catalog/11336.html

APPENDIX-1: Sample Surveys: ___Physics___ Graduate STUDENT INTEREST SURVEY

Based upon the attached description of an **MSc in Material Science** proposed graduate degree, please help us to assess the value and need for establishing such a degree by completing the following survey.

1. Your present profession: ____
2. Your current job title: ____
3. Employed by: ____
4. Location: ____
5. Highest degree earned ______________ overall GPA ____________
6. To what extent are you interested in pursuing studies toward a Graduate Degree? This one or some other one?

   ☐ Very ☐ Moderately ☐ Not at all

7. What would you hope to gain from completing this program? (Check all that apply)

   ☐ upward mobility in current employment

   ☐ increased research experience

   ☐ new position with another employer

   ☐ upgraded knowledge

   ☐ additional personal development

   ☐ other (specify)

8. Would you enroll in the proposed Graduate Degree Program if one were to be established in the next:

   2-3 years ☐ yes ☐ no

   3-5 years ☐ yes ☐ no

   5-7 years ☐ yes ☐ no

9. If your answer to #7 was "yes," would you attend:

   ☐ Full-time ☐ Part-time

10. Indicate your availability to participate in classes:

    ☐ daytime only

    ☐ evenings only

    ☐ daytime/evening combination

- weekends
- electronic access (24 hours)

11. Indicate your preference for courses that can be completed in:

    - one month
    - 12 weeks
    - one semester

12. What period of time would you be able to commit in completing this program?

    - less than 1 year
    - 3-4 years
    - 1-2 years
    - 5-7 years
    - 2-3 years
    - whatever time it takes

13. What relevant skills/experience do you have?

    ____
    ____
    ____
    ____

14. Would your current employer provide any of the following? (Check all that apply)

    - tuition and fees
    - mentored support
    - release time to attend classes
    - paid leave
    - research facilities

15. Are you able to travel within the country to complete your degree studies? ☐ yes ☐ no

Temporarily for one year	☐ yes	☐ no
One semester	☐ yes	☐ no
Weekly commutes	☐ yes	☐ no

16. What would be your preference as to how courses are delivered?

    - traditional lectures
    - online
    - laboratory-based
    - at home
    - at place of employment
    - at the university

17. Would your computer knowledge/ability allow you to use computer-based technology for educational purposes?

    - yes
    - no

18. Would you have access to the required equipment if the program is offered through distance learning? (Check all that apply)

    - audio tape
    - computer
    - Internet
    - television
    - CD rom
    - email
    - multi-media
    - video tape

19. Would you require university financial assistance to pursue this degree? ☐ yes ☐ no
20. Make any comments or suggestions regarding this proposed graduate program.

    ____
    ____
    ____
    ____
    ____

21. If this program moves forward, would you like to be kept informed ☐ yes ☐ no

Thank you so much for sharing your interest and insight.

APPENDIX-2: Sample Surveys: __Chemistry__ Graduate STUDENT INTEREST SURVEY

Based upon the attached description of an **MSc in Material Science** proposed graduate degree, please help us to assess the value and need for establishing such a degree by completing the following survey.

22. Your present profession: ____
23. Your current job title: ____
24. Employed by: ____
25. Location: ____
26. Highest degree earned ________________ overall GPA ______________
27. To what extent are you interested in pursuing studies toward a Graduate Degree? This one or some other one?

    ☐ Very ☐ Moderately ☐ Not at all

28. What would you hope to gain from completing this program? (Check all that apply)

    ☐ upward mobility in current employment

    ☐ increased research experience

    ☐ new position with another employer

    ☐ upgraded knowledge

    ☐ additional personal development

    ☐ other (specify)

29. Would you enroll in the proposed Graduate Degree Program if one were to be established in the next:

    2-3 years ☐ yes ☐ no

    3-5 years ☐ yes ☐ no

    5-7 years ☐ yes ☐ no

30. If your answer to #7 was "yes," would you attend:

    ☐ Full-time ☐ Part-time

31. Indicate your availability to participate in classes:

    ☐ daytime only

    ☐ evenings only

    ☐ daytime/evening combination

- ☐ weekends
- ☐ electronic access (24 hours)

32. Indicate your preference for courses that can be completed in:

☐ one month ☐ 12 weeks ☐ one semester

33. What period of time would you be able to commit in completing this program?

☐ less than 1 year ☐ 3-4 years ☐ 1-2 years
☐ 5-7 years ☐ 2-3 years ☐ whatever time it takes

34. What relevant skills/experience do you have?

____
____
____
____

35. Would your current employer provide any of the following? (Check all that apply)

☐ tuition and fees ☐ mentored support

☐ release time to attend classes ☐ paid leave ☐ research facilities

36. Are you able to travel within the country to complete your degree studies? ☐ yes ☐ no

Temporarily for one year	☐ yes	☐ no
One semester	☐ yes	☐ no
Weekly commutes	☐ yes	☐ no

37. What would be your preference as to how courses are delivered?

☐ traditional lectures ☐ online ☐ laboratory-based

☐ at home ☐ at place of employment ☐ at the university

38. Would your computer knowledge/ability allow you to use computer-based technology for educational purposes?

☐ yes ☐ no

39. Would you have access to the required equipment if the program is offered through distance learning? (Check all that apply)

☐ audio tape ☐ computer ☐ Internet ☐ television

☐ CD rom ☐ email ☐ multi-media ☐ video tape

40. Would you require university financial assistance to pursue this degree? ☐ yes ☐ no
41. Make any comments or suggestions regarding this proposed graduate program.

____
____
____
____
____

42. If this program moves forward, would you like to be kept informed ☐ yes ☐ no

Thank you so much for sharing your interest and insight.

APPENDIX-3: Sample Surveys: EMPLOYER INTEREST SURVEY

Based upon the attached description of a proposed **MSc Degree in Material Science**,

please help us to assess the value and need for establishing such a degree by completing the following survey.

1. Company/Institution name: ____

2. Type of industry/business: ____

☐	agriculture	☐	insurance	☐	service
☐	banking/finance	☐	manufacturing	☐	transportation
☐	education	☐	public utility	☐	federal/state
☐	health care	☐	retail	☐	other

3. Your title: ____

4. In your opinion, is there a need for the proposed program?

   ☐ Strong need ☐ Moderate need ☐ No need

5. Would graduates of this program be given preference over baccalaureate/First Degree and/or other graduate degree candidates for the same position?

   ☐ yes ☐ no

   If no, please explain:

____

____

6. Would you provide support to current employees to pursue such a Graduate Degree?

   ☐ yes ☐ no

   If the answer is "yes", what type of support would you consider? (Check all that apply)

☐	tuition and fees	☐ mentored support
☐	paid time to attend classes (flextime)	☐ paid leave
☐	access to research facilities	☐ child care

☐ other: ____

7. Identify those areas of professional knowledge or research that will be important for your organization in the next decade:

____

____

____

8. What aspects of the proposed program are of most interest/importance to you?

____

____

9. What aspects are of least interest/importance to you?

____

____

10. Make any comments or suggestions regarding the proposed program that you may have:

Course content:

____

Time to degree:

____

Research experience:

____

Professional experience:

____

Internship:

____

11. What is your overall assessment of this proposed program? Does it make sense? What are its strengths/limitations?

____

____

12. Who else (individuals/agencies, etc.) within your network should be informed of this initiative?

____

____

Thank you so much for sharing your interest and insight.