1.5.2 Description of courses

MS7001 Materials Laboratory Techniques
AUs: 3
Prerequisites: NIL
Semester: 1 and 2
In this subject, students will be introduced to the principles and operation of selected materials characterization instruments. The emphasis is on thorough grounding of the principles of measurement and data interpretation. All of the instruments selected find extensive use in materials research. At the end of the course, the student is expected to be trained on the use of each instrument. There will be no final exam. Assessment will be done in the laboratory.

MS 7004 Graduate Seminar
AUs: NIL
Prerequisites: NIL
Semester: NIL
Seminars will be given by distinguished visiting scientists/researchers. Students have to attend two seminars and prepare a detailed critique which will be evaluated by a panel of MSE representatives from various research areas. The student will present a synopsis of the seminars and be assessed by a panel of examiners. Evaluation will be based on the critique. As this is a pass/fail course, there will be no final exam for this subject.

MS 7023 Advanced Polymer Engineering
AUs: 3
Prerequisites: MS2010 or equivalent
Semester: NIL
This advanced course in polymer engineering is intended to provide students with fundamentals of theoretical backgrounds in the physics of polymer behavior, and some of the most current topics in polymer science and engineering research. This course consists of the following: Multiphase polymer systems including copolymers and blends; Phase separation and phase mixing; Morphology and microstructure development; Applications; Filled polymer systems including mechanisms of reinforcement and toughening; Mechanical modeling of multiphase polymers; Advanced processing techniques and applications; Structure and property analysis of polymers using modern analytical techniques: Spectroscopic methods; Dynamic mechanical and rheological tests; Physiochemical techniques

MS 7032 Optoelectronic Materials
AUs: 3
Prerequisites: MS2008 or equivalent
Semester: NIL
Optoelectronic devices convert light to electricity and vise versa. These devices, together with optical fibers, have helped to usher us into the information age. This graduate course is designed to provide a basic understanding on the principles of optoelectronics, including materials processing and characterization, device operation principles, fabrication and characterization.

MS 7033 Electronic Properties of Solids
AUs: 3
Prerequisites: NIL
Semester: NIL

This course presents a unified framework of solid state physics and chemistry for understanding most physical properties of solid state materials, and forms the basis for much of semiconductor physics and devices. It covers the fundamental concepts underlying disciplines such as microelectronics and optoelelectronics with in-depth, quantitative derivations of important electronic parameters of materials.

On completion of the course, students should be able to:
- Understand the theoretical aspects of the electronic and thermal structures of materials

- Understand various theoretical models for calculating energy bands in materials
- Understand the models behind thermal and electrical conductivity
- Understand simple models of dielectric, optical and magnetic properties of materials
- Understand the applications of solid state physics in the theory of semiconductors

MS 7070 Scanning Tunnelling Microscopy (STM) and Molecular Self-Assembly
AUs: 3
Prerequisites: NIL
Semester: NIL
This course will introduce students to scanning tunneling microscopy (STM) and molecular self assembly on various surfaces. The course will also include a hands-on session on a scanning tunneling microscope with STM on alkanethiols on Au and graphite surfaces. (The lecturer will be Prof Dennis Fichou, Visiting Professor from CNRS, France). At the end of the course, the student is expected to understand the fundamentals of both STM and self-assembling systems; the use of STM to probe self-assembled layers; differentiating between chemisorbed and physisorbed structures.

MS 9002 Thermodynamics of Materials
AUs: 3
Prerequisites: MS2006
Semester: 2
This unit is an advanced course built on the knowledge gained in the introductory classes in Thermodynamics & Phase Transformations (SM107/ME107). This course is designed for post-graduate students and aims to provide an in-depth understanding on the principles of thermodynamics of materials and applications to production of inorganic materials, selection of materials for hostile environments, adsorption and chemisorption processes, energy conversion devices, surfaces and interfaces, defects in solids, phase equilibria and phase transformations, statistical and nonequilibrium thermodynamics

MS 9003 Materials Characterization
AUs: 3
Prerequisites: NIL
Highly recommended: MS2007/MS3007, MS8202, MS4553
Semester: 1 and 2
This course will educate on the use of complementary materials characterization techniques through understanding the advantages and limitations of commonly used analytically different X-ray and electron microscopy characterization tools. Students will be acquainted with the principles, instrumentation and operation of X-ray diffraction (XRD), scanning/transmission electron microscopy (SEM/TEM) and x-ray photoelectron spectroscopy (XPS) for characterization of materials. Practical methods of designing experiments, sample preparation, data collection / interpretation will be highlighted. The student should gain an understanding of the importance of these tools individually and complementary to each other in designing and solving materials-related problems.

MS9005 Statistical Analysis of Experimental Data
AUs: 2
Prerequisites: NIL
Semesters: NIL
This course intended to teach the fundamentals and essential techniques in statistical analysis of data. Topics discussed will include detailed statistical review, estimation, hypothesis testing, regression analysis including analysis of variance and error analysis. Sample data will be analyzed using these techniques during lab hours using software packages like ANOVA. Students are expected to understand the statistical data analysis methods and be able to analyze experimental data using the techniques discussed

MS9010 Crystal Chemistry: Theory & Practice
AUs: 3
Prerequisites: MS9003
Highly recommended: MS4553, MS8202
Semester: 1 and 2

This advanced course provides students with the tools needed to undertake state-of-the-art characterisation of inorganic and metallic materials. Key components include:

- Developing an appreciation of the crystallographic and crystal chemical concepts that underpin the collection of data by electron microscopy and X-ray and neutron diffraction, the subsequent interpretation of the data, and its significance in terms of materials processing.
- Understanding the principles that govern the assembly and modification of technologically important oxide crystal systems at the atomic scale.
- Designing practical experiments, especially with respect to preparing samples and collecting data appropriately.
- Appreciating the importance of these methods as nanometric tools in materials science and engineering.

MS9011 Crystallographic Analysis of Materials
AUs: 3
Prerequisites: MS9003, MS9010, MS8202
Semester: 1 and 2
This advanced course provides students with the tools required to perform state-of-the-art crystallographic analysis of materials:

- Comprehensive understanding of X-ray and neutron diffraction techniques and instrumentation and their expert use for materials characterisation.
- Designing diffraction experiments by optimizing all available parameters for specific purposes such as, quantitative phase analysis or crystallographic analysis.
- Data reduction by powder pattern decomposition, indexing and profile fit and refinement. Structure solution employing the Monte-Carlo method, crystallographic similarities and Fourier analysis.
- Structure refinement using the Rietveld method both with the Fundamental Parameter Approach and the Analytical Profile Approach.
- Develop an understanding which approach is most appropriate for which task.

MS9012 Surface Analysis of Materials
AUs: 3
Prerequisites: MS9003, MS9010
Semester: 1 and 2
This course will provide training in X-ray photoelectron spectroscopy (XPS) to analyze monitor and characterize materials surfaces. Fundamental understanding of the theory, practice and applications of photoelectron spectroscopy for surface analysis will be provided. Extensive training in XPS instrumentation, sample preparation, data acquisition and data interpretation.

- Designing practical experiments to study the surface of materials using XPS
- Critical reading of surface analysis reports
- Hands on training and problem solving using Computer Aided Surface Analysis (CASA) XPS software

MS9013 Nanometric Analysis of Materials
AUs: 3
Prerequisites: MS9003, MS9010, MS4553
Semester: 1 and 2
The morphology, structure and local chemistry of metals, ceramics and minerals is an important aspect of contemporary materials science. The Transmission Electron Microscope (TEM) is an analytical tool that allows detailed microstructural examination through high-resolution and high magnification imaging. It also enables the investigation of crystal structures, orientations and chemical compositions of phases, precipitates and contaminants through diffraction pattern, X-ray and electron-energy analysis. The TEM is not a single instrument, but a platform, to which various spectroscopic and nanometric tools are fitted. Microscopists specialise in one or at most two of the many available tools.

MS9020 Advanced Topics in Polymer Chemistry
AUs: 3
Prerequisites: MS2010
Semester: 1

This course aims to cover selected advanced topics in the chemistry of polymers. The course will cover 3 different parts, i.e.:

- Radiation Curing & Coatings
- Composites & Nanocomposites
- Polymer Synthesis / High-Performance Polymers

One of the objective of the course is to expand the knowledge of graduate students regarding synthesis of new classes of advanced polymers and composites as well as new technologies used for processing and for performance applications.

MS9021 Polymer Physical Science
AUs: 3
Prerequisites: MS 2010 (Polymers & Composites) or equivalent
Semester: NIL
This advanced course in polymer science is intended to provide students with fundamentals of the physics of polymer behavior, and some of the most current topics in polymer science and engineering research. This course emphasizes physico-chemical aspects of polymers, such as viscoelasticity, solution properties, the amorphous and crystalline states.

MS9022 Biomedical Polymers
AUs: 3
Prerequisites: MS4001; MS2010
Semester: 2
This advanced subject in polymer engineering is intended to provide students with fundamentals of polymer use in biomedical applications, as well as of the relevant advanced polymer characterisation techniques including the in-vitro and in-vivo testing methods. The subject discusses both synthetic and natural polymers. The emphasis is on the relationship of structure to function in a biological setting.

MS 9030 Nano and Molecular Electronics
AUs: 3
Prerequisites: MS2008
Semester: 2

This course will introduce students to area of significance to the future of electronics:

- Nanoelectronics
- Molecular Electronics
- Top-down fabrication including lithography & nanostructure formations
- Bottoms' up fabrication including self assembly and self organization

In each class, the emphasis will be on the trends in newer, improved materials, processes, and novel devices that will continue to advance the staggering pace of the electronics industry and applications worldwide.

MS 9031 Organic Electronics Materials & Devices
AUs: 3
Prerequisites: MS2010, MS2008
Semester: 2

This course will introduce students to area of polymer electronics materials, processing, and applications. It ranges from introduction to synthetic chemistry to device fabrication, materials characterization, and device and materials physics.
This course consists of:

- Fundamentals of Organic Electronic Materials
- Materials & Materials Synthesis
- Device Physics & Characterization
- Devices & Processing
- Applications, Roadmaps

MS 9040 Advanced Ceramics
AUs: 3
Prerequisites: MS3001
Semester: 1
This is an advanced course built on the knowledge gained in the Metallic & Ceramic Materials (MS 3001) and Inorganic materials nanostructure (MS480)**.** This course is designed for postgraduate students and aim to provide an in-depth understanding of different mechanisms in ceramic materials.
On completion of the course the student should be able to understand the following topics:

- Relationship between the structure of ceramics and their mechanical properties
- Advanced processing techniques for ceramics
- Influence of the interfaces by absoption, chemi-sorption and temperature
- Electrical properties of linear and non-linear dielectrics including piezo- and ferro-electric materials
- Structure and properties of linear and non-linear magnetic materials and their applications
- Structure and properties of electro-optic ceramics and their application
- Thin film fabrication and characterization

MS 9045 Computer Modelling of Materials
AUs: 3
Prerequisites: MS 2008, FE1008
Semester: 2
Computer simulation is used to explore, explain and predict the properties of materials. This course is designed for students with varied skills and background (previous experience in computer modeling is not required), and to provide an understanding on the principles, techniques and applications of simulation mainly at the atomic scale. We will focus on problems important for material science. This should enable the student to: (1) make sound judgements regarding the quality of computational studies reported in the literature; (2) decide whether molecular simulation is suited for application to their research, and if so, to know how to begin developing a simulation program applicable to their problems. Hand-on sessions using various techniques ranging from quantum mechanical, molecular dynamics, Monte Carlo will also be conducted.
On completion of the course the student should be able to:

- Understand the principles of quantum mechanical simulation
- Understand the principles of molecular dynamics method
- Understand the principles of Monte Carlo technique
- Understand and appreciate the various possible areas of application using the above techniques

MS 9051 Advanced Nanomaterials
AUs: 3
Prerequisites: MS4552
Semester: NIL
This advanced subject on nanomaterials is intended to provide students with fundamentals in structural, mechanical and physical properties of nanostructured materials, as well as their relevant functions. The subject discusses a variety of fabrication techniques for nanostructures, related transport phenomena and kinetics at this scale. The emphasis is to lead students into the nanofield and prepare them for future scientific and technological exploration through discussing some typical nanomaterials such as zeolites, nanoarrays, multilayers, mesoporous materials and bioclastic nanostructures. The main objectives are to 1) Develop an understanding for nanomaterials technology. 2) Learn to search the literature on current research topics. 3) Develop an understanding of new techniques used in studying nanomaterials. 4) Understand some of the theory describing differences between nanomaterials and bulky materials.

MS 9052 Surfaces and Colloids
AUs: 3
Prerequisites:NIL
Semester: 1

This short course is intended to acquaint students with the fundamentals of colloids and surfaces. Students will learn about theories of surface wetting, measurement techniques for surface characterization, colloidal forces and stability of colloidal particles. This course is a must for students working in nanoparticles, surfaces and interfaces of materials.

The lecturer is Professor Abraham Marmur, who is the Albert and Anne Mansfield Chair in Water Science and Technology, Chemical Engineering Department, Technion – Israel Institute of Technology, Haifa, Israel

MS 9053 Membrane Biophysics
AUs: 3
Prerequisites: NIL
Semester: NIL
This course will introduce students to the area of membrane biophysics, and will focus on interfacial effects, lipid monolayers at the air/water interface, multilamellar lipid- water systems, bimolecular lipid membranes, tethered lipid membranes, and applications of these membranes.

This course consists of lectures on:
- Fundamentals – architecture of the cell
- Interfacial effects
- Monomolecular lipid layers
- Multilamellar lipid-water systems
- Bimolecular lipid membranes (BLMs)
- Tethered lipid membranes (tBLMs)
- Applications