# College of Science

## KOLEHIYO NG AGHAM

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*The University's first science departments, namely, Botany, Chemistry, Mathematics, and Zoology, were organized on 03 June 1910, under the College of Liberal Arts, later renamed the College of Arts and Sciences (CAS). In 1976 the CAS was reorganized into three (3) divisions: Division of Humanities, Division of Social Sciences, and Division of Natural Sciences and Mathematics, with the latter consisting of seven departments: Botany, Chemistry, Geology and Geography, Mathematics, Meteorology and Oceanography, Physics, and Zoology.*

*On 26 October 1983, the Board of Regents approved the partition of the CAS into three (3) new colleges: College of Arts and Letters, College of Social Sciences and Philosophy, and College of Science with the latter being organized out of the Division of Natural Sciences and Mathematics (excluding Geography). The College of Science (CS) started operating as a separate college on 19 December 1983, when Dr. Roger Posadas was appointed as its first Dean, who served the college up to his appointment as Chancellor of UP Diliman in November 1993. The deans who succeeded Dr. Posadas are: Dr. Danilo Yanga (1993-1999); Dr. Rhodora Azanza (1999-2006); Dr. Caesar Saloma (2006-2011), and Dr. Jose Maria Balmaceda (2011 – present).*

*The CS is the largest college in UP Diliman in terms of regular faculty size and second largest in student enrolment. It is the acknowledged national center of excellence for advanced education and research in the natural and mathematical sciences. Its faculty has the country's largest concentration of PhD scientists and its undergraduate, graduate, and research programs conform to international standards of excellence. It leads the whole UP system in the publication of refereed scientific articles in reputable national and international journals.*

*As of 2013, five (5) units of the College have been declared "National Centers of Excellence" through Executive Orders and Proclamations of the President of the Republic, namely, the National Institute of Physics (NIP), National Institute of Geological Sciences (NIGS), Natural Sciences Research Institute (NSRI), Marine Science Institute (MSI), and National Institute of Molecular Biology and Biotechnology (NIMBB). The latter is part of the country's Network of National Institutes of Molecular Biology and Biotechnology.*

*The Commission on Higher Education (CHED) has declared several units of the College as "Centers of Excellence" (COE) in basic sciences; namely, the Institute of Mathematics, Institute of Biology, Institute of Chemistry, MSI, NIP, NIGS, and NIMBB. The COE status of these units is renewable upon satisfactory performance evaluation by CHED.*

*The long-term goal of the College is to become a world-class center of excellence for advanced scientific education and research. Its primary mission is to contribute to the advancement of science and technology in the Philippines through high-quality science education, the acquisition of scientific and technological knowledge, and the provision of scientific and technical services. The College performs three main functions:*

- *To provide international-quality graduate and undergraduate education in the natural and mathematical sciences.*
- *To undertake basic and applied scientific research that is of high standard and national relevance.*
- *To render technical extension services in support of national scientific and technological development.*

## ORGANIZATIONAL STRUCTURE

The College presently has eight (8) degree-granting institutes, namely:

- National Institute of Geological Sciences (NIGS)
- National Institute of Molecular Biology and Biotechnology (NIMBB)
- National Institute of Physics (NIP)
- The Marine Science Institute (MSI)
- Institute of Biology (IB)
- Institute of Chemistry (IChem)
- Institute of Environmental Science and Meteorology (IESM)
- Institute of Mathematics (I-Math)

In addition, the CS has two (2) interdisciplinary programs, namely:

- Science and Society Program (SSP)
- Materials Science and Engineering Program (MSEP), and one attached unit, namely, Natural Sciences Research Institute (NSRI)

The MSEP is jointly administered with the College of Engineering and offers MS and PhD programs. The NSRI undertakes research and provides technical and analytical services through its in-house laboratories. It also administers a grants program for researchers in biology, chemistry, mathematics, environmental sciences, and meteorology.

The support facilities of the College include:

- CS Library (with satellite libraries in the different institutes)
- Computational Science Research Center (CSRC)
- Bolinao Marine Laboratory.

The College is headed by the Dean who is assisted by three Associate Deans, the College Secretary, and a Coordinator for each interdisciplinary program. Each institute is headed by a Director. Collective management of the College is exercised by the College Executive Board composed of the Dean, Associate Deans, Secretary, Directors, and Coordinators. The highest policy-making authority within the College is the College Assembly composed of all the regular faculty members and university researchers of the College.

## PROGRAMS OFFERED

## UNDERGRADUATE PROGRAM

The College currently offers seven (7) baccalaureate programs:

- Bachelor of Science in Biology
- Bachelor of Science in Chemistry
- Bachelor of Science in Geology
- Bachelor of Science in Mathematics
- Bachelor of Science in Molecular Biology and Biotechnology
- Bachelor of Science in Physics
- Bachelor of Science in Applied Physics (Instrumentation Physics; Materials Physics)

The physics and applied physics programs are five-year programs, while the rest are four-year programs. The BS Geology program requires an undergraduate research paper for its students; the rest of the BS programs of the College require an undergraduate thesis.

## SPECIAL POST-BACCALAUREATE UNDERGRADUATE DIPLOMA PROGRAMS

The College offers one-year diploma programs in biology, chemistry, mathematics, and physics, consisting of selected undergraduate major courses. The programs are especially designed for college teachers in these disciplines who have inadequate undergraduate training therein and who wish to upgrade their knowledge and skills in preparation for advanced studies. The diploma programs in meteorology and environmental science are one-year graduate programs.

## GRADUATE PROGRAMS

The College offers thirteen (13) Master of Science programs, a Professional Masters in Applied Mathematics program, and ten (10) Doctor of Philosophy programs. In addition there are four (4) special post-baccalaureate programs at the graduate level. These are:

Special Post-Baccalaureate Programs: Diploma in Meteorology; Diploma in Environmental Science; Diploma in Chemistry; Diploma in Mathematics; Master of Arts in Mathematics, and Master of Arts in Physics

MS: Applied Mathematics, Biology, Chemical Education, Chemistry, Environmental Science, Geology, Marine Science (marine biology, marine biotechnology, marine physical sciences), Materials Science and Engineering, Mathematics, Meteorology, Microbiology, Molecular Biology and Biotechnology, and Physics.

Professional Masters: Applied Mathematics (Actuarial Science) and Professional Masters in Tropical Marine Ecosystems Management.

PhD: Biology, Chemistry, Environmental Science, Geology, Marine Science (Marine Biology, Marine Physical Science, Marine Biotechnology), Materials Science and Engineering, Mathematics, Meteorology, Molecular Biology and Biotechnology, Physics, Biology (Option 3), and Marine Science (Option 3).

**ADMISSION REQUIREMENTS/POLICIES**

**UNDERGRADUATE**

Applicants for admission to the baccalaureate programs of CS must satisfy the University requirements for admission. Undergraduate students who wish to transfer to CS from other colleges/units of the University or from other universities may be admitted under current CS admission policies.

Applications for transfer to CS shall be accepted and processed only for the first semester of each school year. Admission into a BS program shall depend on the final approval of the institute/department offering the program.

**Transferee From Within UP**

An applicant may qualify for admission into CS after completion of two or more semesters or at least thirty 30 units of courses with a general weighted average of 2.5 or better.

The number of transfer students to be admitted into CS each school year shall depend on the number of undergraduate majors that can be accommodated by each institute/department.

All BS degree programs of CS are open to transfer students from other UP colleges/units, but admission will depend on the availability of slots.

**Transferee From Outside UP**

Applicants for transfer from outside UP to CS must first satisfy the UP rules on admission of transfer students and then comply with the following CS policies:

An applicant who qualified under the UPCAT but enrolled in another school may be admitted into CS after completion of two or more semesters or at least thirty-three (33) units of courses outside UP with a general weighted average of 1.75 or better.

An applicant who did not qualify under the UPCAT may be admitted into CS after completion of two or more semesters or at least thirty-three (33) units of courses outside UP with a general weighted average of 1.50 or better.

**Admission Requirements for Diploma Programs**

An applicant for admission into the diploma programs must:

1) Possess a bachelor's degree from a recognized institution of higher learning
2) Have completed the following undergraduate units:
   a) For Diploma in Biology—at least fifteen (15) units of college biological sciences and at least 10 units of college chemistry including general and organic chemistry

   b) For Diploma in Mathematics and Diploma in Physics—at least fifteen (15) units of college mathematics up to differential and integral calculus

   c) For Diploma in Chemistry—at least twenty (20) units of college chemistry, including quantitative analysis and elementary organic chemistry, ten (10) units of college physics, and fifteen (15) units of college mathematics including differential and integral calculus

   d) For Diploma in Meteorology—a strong background in physics and mathematics

3) Pass an entrance examination or placement examination where required

To obtain the undergraduate Diploma in Biology, Chemistry, Mathematics, or Physics, the student must complete the following courses (or equivalent/substitute courses approved by the unit):

a) Diploma in Biology—Chem 40, 40.1, Bio 121, 122, 133, 140, 150, 160. Total Units: 34
b) Diploma in Chemistry—Chem 34, 34.1, 112, 123, 123.1/125, 145, 146.1,153, 154, 156, 196, 252. Total Units: 30-32
c) Diploma in Mathematics—Math 109, 55, 110.1, 114, 117, 123.1, 128, 196, CS 11, Stat 101. Total Units: 30
d) Diploma in Physics—Physics 101, 101.1, 102, 102.1, 103, 103.1, 111, 112, Math 121.1. Total Units: 24

The following are the requirements for the graduate diploma programs:

a) Diploma in Environmental Science—1) at least twenty (20) units of formal graduate courses; 2) a cumulative weighted average grade (CWAG) of 2.00 or better at the end of each academic year; and 3) a 1-unit seminar course.
b) Diploma in Meteorology—1) at least twenty (24) units of formal graduate courses in meteorology and 2) a CWAG of 2.00 or better in these courses.

In addition to University rules and regulations governing graduate programs, the following apply to the CS master's and doctoral programs.

**Master of Arts**

The MA (Mathematics) and MA (Physics) programs are primarily intended for college teachers in these disciplines who do not possess a BS in Mathematics or a BS in Physics degree, respectively. These programs aim to upgrade the teacher's knowledge of their subject matter so as to improve their teaching competence in these disciplines and to prepare them for further advanced studies.

Admission into the MA (Mathematics) program requires completion of college-level courses in algebra, trigonometry, analytic geometry, and calculus. To earn the degree, students must complete thirty-three (33) units of mathematics courses, one (1) unit of a graduate seminar, and pass a comprehensive examination.

Admission into the MA (Physics) program requires completion of

the equivalent courses in the Diploma in Physics program. To earn the degree, students must complete thirty-nine (39) units of physics courses, one (1) unit of a physics seminar, five (5) units of a teaching seminar, and the 3-unit course in Science, Technology and Society, and pass a comprehensive examination.

**Master of Science**

The MS degree may be obtained through either of the following two options:

Thesis Option—To qualify for the MS degree under this option, a student must satisfy the following requirements: 1) complete a minimum of twenty-four 24 units of formal graduate courses; 2) maintain a CWAG of 2.00 or better in his graduate courses at the end of each academic year; 3) complete one (1) unit of graduate seminar; 4) successfully defend a master's thesis in a master's examination; and 5) submit at least six (6) bound and certified copies of the approved master's thesis.

Non-Thesis Option—To qualify for the MS degree under this option, a student must satisfy the following requirements: 1) complete a minimum of thirty-three (33) units of formal graduate courses; 2) maintain a CWAG of 2.00 or better in his/her graduate courses at the end of each academic year; 3) complete one (1) unit of graduate seminar; 4) pass the master's preliminary examination; and 5) pass the comprehensive examination.

*Placement Examination*

A student may be required by the Graduate Committee to take a placement examination. A student who does not perform satisfactorily in this examination or who has deficient academic preparation may be required to complete appropriate undergraduate remedial courses in the College.

*Master's Examination*

Upon completion of the master's thesis and its endorsement by the thesis adviser and thesis reader to the Graduate Committee, the latter shall recommend to the Dean the formal appointment of two thesis examiners who, together with the thesis adviser and thesis reader (plus the thesis co-adviser, if any) shall constitute the master's examination panel of four (4) or five (5) members. The thesis reader or one of the thesis examiners shall be elected by the thesis adviser to chair the master's examination panel.

Acceptance of the thesis defense by at least three (3) out of four (4) or four (4) out of five (5) members of the master's examination panel shall merit the rating of "Pass," while rejection of the thesis defense by at least two panel members shall incur the rating of "Fail." Any other combination of acceptance, conditional acceptance/rejection of the thesis defense in between these two extremes shall result in a rating of "Provisional Pass." A vote of rejection by a panel member must be explained in writing.

*Preliminary Examination*

This written and/or oral examination has to be taken by a student in the non-thesis option within one year after completing the core courses in his program of study.

*Comprehensive Examination*

This oral examination must be taken by a student in the non-thesis option after he/she has passed the preliminary examination and completed all the course and seminar requirements for the MS degree. In this examination, the student is required, among other things, to give a seminar on a topic covering a recent development in the discipline.

*Disqualifications*

A student shall be disqualified from the MS program in case of:

1) Failure to satisfy the CWAG requirement of 2.00 (unless the graduate committee decides, on justifiable grounds and upon the recommendation of the student's program adviser, to put him on probation for one [1] to two [2] semesters).
2) Failure to obtain the minimum CWAG after the probation period shall automatically disqualify the student from the MS program;
3) Failure in the second master's examination;
4) Failure in the second preliminary examination;
5) Failure in the second comprehensive examination;
6) Non-compliance with the Maximum Residence Rule (MRR); and
7) Absence without official leave (AWOL).

**Doctor of Philosophy**

The general requirements for any PhD degree in the College are the following:

Completion of a program of study consisting of at least forty-five (45) units of formal graduate courses in the case of students admitted into the PhD program with only a BS degree in the discipline or a master's degree in an unrelated discipline, and of at least twenty-four (24) units of formal graduate courses in the case of students admitted into the PhD program with an MS degree in the discipline;

Maintenance of a CWAG of 1.75 or better at the end of each academic year until completion of the program of study;

Passing of the qualifying examination based on the core courses;

Passing of the candidacy examination after completion of all course work in the student's program of study;

Completion of at least one (1) unit of a graduate seminar during the student's course work and participation in a Graduate Research Colloquium of the College at least once every two years by giving a seminar on the progress of the dissertation work;

Completion of a doctoral dissertation based on an independent and original research;

Successful defense of the doctoral dissertation in a public doctoral examination;

Submission of a publication or an acceptance letter from a reputable, refereed scientific journal as defined by the unit and approved by the Dissertation Committee; and

Submission of at least six (6) bound paper copies and a CD copy of the approved doctoral dissertation based on the approved College of Science format.

Additional requirements and higher standards over and above these common minimum College requirements and standards for the PhD degree may be adopted by a graduate committee for its PhD program upon endorsement by the Graduate Faculty Council and approval by the University Council.

*Placement Examination*

An admitted student may be required by the graduate committee concerned to take a placement examination. Depending upon the result, s/he may be required to complete appropriate undergraduate remedial courses in the College.

*Qualifying Examination*

This examination, written and/or oral, is taken by the student within one year after completion of the core courses in his program of study. An MS degree holder in the discipline may be exempted from the examination by the graduate committee concerned.

*Candidacy Examination*

The Candidacy Examination is an oral and/or written examination that must be taken by the student after 1) passing the Qualifying Examination, 2) completing the course work in his/her program of study, 3) obtaining a CWAG of "1.75" or better in his/her course work, and 4) completing the courses as stipulated by the College residence rules. In this examination the student is required to give a seminar on an approved research topic in his/her chosen field of specialization and is examined on his/her a) grasp of this chosen field of specialization, b) mastery of the basic principles and methods of the discipline, and c) readiness for dissertation research in the chosen field of specialization.

*Seminar Requirements*

Prior to the candidacy examination, the student must complete at least one (1) unit of graduate seminar as an additional requirement on top of the formal course requirements in his program of study. After advancing to PhD candidacy, he/she must also participate, at least once every two years, in the Graduate Research Colloquia of the College by giving a seminar on the progress of his/her dissertation research.

*Doctoral Examination*

The Doctoral Examination (dissertation defense) may be held only upon completion of the doctoral dissertation and its endorsement by the Dissertation Committee to the Graduate Committee.

The Doctoral Examination may be given either of the following ratings: "Pass," if the dissertation defense is deemed acceptable; "Provisional Pass," if the dissertation defense is deemed acceptable subject to certain minor revisions of the dissertation in form or content; or "Fail," if the dissertation defense is deemed unacceptable.

Acceptance of the dissertation defense by at least four (4) members of the Doctoral Examination Panel shall merit the rating of "Pass," while rejection of the dissertation defense by at least two (2) Panel members shall incur the rating of "Fail," Any other combination of acceptance, conditional acceptance and/or rejection of the dissertation defense in between these two extremes shall result in a rating of "Provisional Pass."

*Dissertation Publication Requirement*

Since AY 2005-2006, a requirement for graduation from the PhD program is the submission to the Graduate Office of proof of acceptance or publication of a technical article in a reputable, refereed scientific journal. The article must be based partly or entirely on the student's approved dissertation and endorsed by the student's Dissertation Committee.

*Disqualifications*

A student shall be disqualified from the PhD program on the following bases:

1) Failure to satisfy the CWAG requirement of 1.75 at the end of the academic year unless the graduate committee decides, on justifiable grounds and upon the recommendation of the student's program committee, to put him/her on probation for a period not exceeding two (2) semesters.
2) Failure to obtain the minimum CWAG after the probation period.
3) Failure in the second qualifying examination.
4) Failure in the second candidacy examination.
5) Failure in the second doctoral examination.
6) Non-compliance with the Maximum Residence Rule.
7) Absence without official leave (AWOL).

**PRIVATE SCHOLARSHIPS**

The College of Science, through the Diliman Science Research Foundation, Inc., administers the following private scholarships: 1) Dr. Jose Maria Feliciano Memorial Scholarships (graduate and undergraduate scholarships for CS students in the geological, physical and biological sciences); and 2) Manulife scholarships (full program or 1-year grants) for CS undergraduate and graduate students who are interested in actuarial science and mathematical finance. Information and application forms may be obtained from the Office of the Associate Dean for Student and Public Affairs. In addition, the University's Office of Scholarships and Student Services located at Vinzons Hall, administers numerous scholarship programs. Several of these scholarships are specifically intended for students majoring in chosen disciplines in the College of Science.

The CS, as a member-university of the National Science Consortium, implements the master's and doctoral scholarship programs under the Advanced Science and Technology Accelerated Human Resource Development Program (ASTHRDP) of the DOST-Science Education Institute. Applications may be submitted to the CS Graduate Office.

## INFRASTRUCTURE AND FACILITIES

### The National Science Complex

The College of Science occupies a 21.9 hectare contiguous area in the southeast sector of the Diliman campus. In 2006, the area was designated as the National Science Complex and Technology Incubation Park (NSC) through Executive Order No. 593. The NSC is home to all the buildings of the College of Science, with a total floor area of around 100,000 square meters. The different institutes of the College have some of the best facilities for research and instruction in the Philippines, including state-of-the art equipment and facilities that meet international standards.

### CS Library

The College of Science Main Library, housed in its own building in the National Science Complex has a fully integrated electronic library system and Web accessible catalog. It is the only library on campus with online subscriptions to index and abstracts databases and full text journals. In addition, there are several institutes, namely, NIGS, I-MATH, IChem, NIP, MSI, and NIMBB, housing satellite libraries and reading rooms. The electronic services are accessible from any of the CS Libraries. All the libraries have electronic online public access catalogs, CD-ROM, and Internet services. The libraries are manned by IT knowledgeable and skilled staff.

### Research Facilities and Laboratories

The College has among the best research facilities in the country. In addition to the laboratories and other facilities of the Institutes, the College also runs the Technology Incubation Core Facility (TICF) program, comprising major research equipment recently acquired by the College for its research programs and technical services.

IB: Freshwater Ecology Laboratory, Plant Tissue Culture Laboratory, Microbiology Laboratory, Ecotoxicology Laboratory, Genotoxicology Laboratory, Physiology Laboratory, Advanced Microscopy Laboratory, Spore and Gametophyte Laboratory, Cell Biology Laboratory, Instrument Room and Preparation Room, Herbarium, Vertebrate and Invertebrate Museums, Greenhouse Facilities, Terrestrial Research in Ecology and Evolution Laboratory, Animal Cell Culture facility, DNA Barcoding Laboratory, Medical Microbiology Research Laboratory, Environmental Microbiology Laboratory, and Biodiversity Research Laboratory

IChem: Analytical Services Laboratory, Biochemistry Research Laboratory, Chemical Thermodynamics Laboratory, Organic Synthesis Laboratory, Electroanalytical Research Laboratory, Inorganic Chemistry Laboratory, Environmental Chemistry Research Laboratory, Polymers Laboratory, Glass Blowing Shop, Balance Room, Materials Science Research Laboratory, Bio-organic Research Laboratory, Natural Products Research Laboratory, Intelligent Inorganic Materials and Bio-Inorganic Research Laboratory, and Advanced Nanomaterials, Sensor and Environmental Research Laboratory (ANSER). Major equipment include two nuclear magnetic resonance (NMR) systems; atomic absorption spectrophotometer, liquid and gas chromatograph-mass spectrometers, Fourier transform-infrared spectrophotometer, high pressure liquid chromatograph, atomic force microscope, ultra-violet visible spectrophotometer, and surface plasmon spectrometer

NIGS: Atomic Absorption Spectrometry Laboratory, Clay Mineralogy Laboratory, Computer Laboratory, Earth Materials Science Laboratory, Earth Resources Laboratory, Electron Probe Micro Analyzer Laboratory, Engineering Geology Laboratory, Environment Monitoring Laboratory, Geochemistry Laboratory, Geomorphology Laboratory, Geophysics Laboratory, ICP-MS Laboratory, LA-ICP Laboratory, Micropaleontology Laboratory, Microscopy Laboratory, Mineralogy Laboratory, Nannoworks Laboratory, NIGS Library, Paleontology Laboratory, Petrology Laboratory, Rock Preparation Laboratory, Rock Storage Room, Rushurgent Working Group, Sedimentology Laboratory, Structural Geology Laboratory, Volcano Tectonics Laboratory, Wet Geochemistry Laboratory, and XRD and XRF Laboratory

MSI Facilities in Diliman: Seaweed chemistry laboratory and pilot plant, Marine genomics and molecular genetics facility, Algal and microbial biotechnology facility, Biochemistry and toxinology laboratories, Marine Chemistry Laboratories, Oceanographic modelling and remote sensing laboratories, Marine sedimentology and core scanner facility, Marine molecular ecology laboratory, Coral museum, GT Velasquez Phycological Herbarium, Seaweed and marine phytoplankton culture rooms, MSI Library and information and database systems, Audio visual/seminar rooms, Cold storage facility, Chemical waste storage, and Animal house facility. UPD-CS Biophysicochemical Techno-Incubation Core Facility (TICF) is housed at MSI Diliman

MSI Facilities at Bolinao Marine Laboratory (BML): Flow through seawater and continuous aeration experimental areas, outdoor culture invertebrates and seaweeds culture facilities, micro algal culture facility, marine microbiological laboratory, scuba diving equipment and support facility, BML library, computer room, analytical instrument and microscopy laboratory, small watercrafts, dormitories and staff housing, audio visual room, conference rooms, and multipurpose hall

MSE Program: Multi-target DC/RF magnetron sputtering systems, thermal and electron beam evaporation facility, high and ultra-high vacuum facility, an arc discharge melting facility, cryogenic systems with instrumentation for magnetic susceptibility and Hall and resistivity measurements, Electron Tunneling facility, high temperature furnaces up to 1,700 $^{o}$C, vertical Liquid Phase Epitaxy (LPE) machine, horizontal Liquid Phase Epitaxy (LPE) machine, a Plasma Enhanced Chemical Vapor Deposition (PECVD) system, crystal growth facility, two Molecular Beam Epitaxy (MBE) systems, cleanroom facilities, photolithographic facility, electron lithography systems, X-ray diffractometer, double crystal High Resolution X-ray Diffractometer, X-ray Flourescence Spectrograph, Scanning Electron Microscope (SEM) and FESEM, Transmission Electron Microscope, Raman Spectroscopy system; Photoluminescence system, Spectroscopic Ellipsometer, Deep Level Transient Spectroscopy system; petrographic, mineragraphic, imaging microscopes; polishing and section preparation equipment; universal testing machine; microhardness testers; reflectivity meter. Support facilities for these equipment are also available like vacuum grade machining, liquid nitrogen support, electronics facility, and other preparation requirements

I-MATH: Undergraduate, graduate and faculty computer laboratories, audio-visual rooms, and Math library

NIMBB: Molecular and Cell Biology Laboratory, Protein Structure and Immunology Laboratory, Nanobiology Laboratory, Molecular Toxicology Research Laboratory, Plant Molecular Biology and Plant Virology Laboratory, Aquatic Biotechnology Laboratory, Molecular Microbiology Laboratory, Functional Genomics Laboratory, and Disease Molecular Biology and Epigenetics Laboratory

NIMBB UP Diliman also hosts two (2) core facilities of the Philippine Genome Center: the DNA Sequencing and Bioinformatics Core facilities

NIP: Condensed Matter Physics Laboratory, Instrumentation Physics Laboratory, Photonics Research Laboratory, Plasma Physics Laboratory, Structure and Dynamics Laboratory, Theoretical Physics Laboratory, Electronics Laboratory, Femtosecond Laser Facility, NIP-Hitachi Metrology Laboratory, NIP Library, Machine Shop, and INTEL Center for Science Innovation (NIP Auditoriums and Seminar Rooms), The NIP also houses the Multi-dimensional Imaging Laboratory ( a Technology Incubation Core Facility)

NSRI: The NSRI was reorganized from the former Natural Sciences Research Center in 1983 under Executive Order 889, with the mandate to promote excellence in the fields of biology, chemistry, environmental sciences, mathematics, and meteorology. As a national center of excellence for research, the NSRI has instituted mechanisms to make the expertise and the facilities of the Institute available to UP researchers, members of the national scientific community, and the public. The Institute maintains modern scientific instruments and facilities and has a pool of specially trained scientists to render research and development as well as analytical services through its four technical laboratories. The institute has four in-house laboratories, namely: Microbiological Research and Services Laboratory (MRSL), Research & Analytical Services Laboratory (RASL), Biological Research Services Laboratory (BRSL), and DNA Analysis Laboratory (DAL)

**BACHELOR OF SCIENCE IN BIOLOGY**
**152-156 units**

APPROVAL
122nd UPD UC : 09 July 2012 | President AEPascual : 01 August 2012

## FIRST YEAR

| 1st Semester (19 units) | | 2nd Semester (20 units) | |
|---|---|---|---|
| Ge (AH 1) Eng 10 | 3 | GE (SSP 2) Kas 1* | 3 |
| GE (SSP 1) Free Choice | 3 | GE (AH 2) Free Choice | 3 |
| Math 17 | 5 | Chem 26 | 3 |
| Chem 16 | 5 | Chem 26.1 | 3 |
| Geol 11 | 3 | BIO 11 | 5 |
| PE | (2) | Math 100 | 4 |
| NSTP | (3) | PE | (2) |
| | | NSTP | (3) |

## SECOND YEAR

| 1st Semester (21 units) | | 2nd Semester (19 units) | |
|---|---|---|---|
| GE (AH 3) Free Choice | 3 | GE (AH 4) Comm 3 | 3 |
| Chem 31 | 3 | GE (MST 1) STS | 2 |
| Chem 31.1 | 2 | Chem 40 | 3 |
| BIO 12 | 5 | Chem 40.1 | 2 |
| BIO 180 | 3 | BIO 101 | 3 |
| Phys 71 | 4 | BIO 102 | 5 |
| Phys 71.1 | 1 | PE | (2) |
| PE | (2) | | |

## THIRD YEAR

| 1st Semester (20 units) | | 2nd Semester (20-21 units) | |
|---|---|---|---|
| GE (AH 5) Fil 40* | 3 | GE (SSP 3) Philo 1 | 3 |
| BIO 120 | 4 | BIO 160 | 5 |
| BIO 150 | 5 | BIO 121[1] | 4 |
| BIO 191 | 3 | BIO 122[1] | 4 |
| BIO 140 | 5 | BIO 123[1] | 3 |
| | | BIO 133 | 5 |

## FOURTH YEAR

| 1st Semester (17-19 units) | | 2nd Semester (16-17 units) | |
|---|---|---|---|
| GE (SSP 4) Free Choice | 3 | GE (SSP 5) Free Choice | 3 |
| GE (MST 2) Free Choice | 3 | PI 100 | 3 |
| Biology Specialty Elective | 3 | BIO 196 | 1 |
| BIO 200a | 2 | BIO 200b | 2 |
| Science Elective | 3 | Biology Specialty Elective | 3 |
| Science Elective | 3-5 | Biology Specialty Elective | 4-5 |

*[1] Any two of the three physiology courses*
** Kas 1 and Fil 40 satisfy the 6-unit Philippine Studies requirement*

*Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

## BACHELOR OF SCIENCE IN CHEMISTRY
**145-149 units**

APPROVAL
135th UPD UC : 24 June 2015 | President AEPascual : 16 March 2016

### FIRST YEAR

| 1st Semester (19 units) | | 2nd Semester (18 units) | |
|---|---|---|---|
| Chem 16 | 5 | GE (AH 2) Comm 3 | 3 |
| Math 17 | 5 | Chem 17 | 5 |
| Geol 11 | 3 | Math 53 | 5 |
| GE (AH 1) Eng 10 | 3 | BIO 11 | 5 |
| GE (SSP 1) Kas 1* | 3 | PE | (2) |
| PE | (2) | NSTP[1] | (3) |
| NSTP[1] | (3) | | |

### SECOND YEAR

| 1st Semester (18 units) | | 2nd Semester (19 units) | |
|---|---|---|---|
| Chem 28 | 3 | GE (SSP 2) Philo 1 | 3 |
| Chem 33 | 3 | GE (SSP3) Free Choice | 3 |
| Chem 101.1 | 3 | Chem 34 | 3 |
| Math 54 | 5 | Chem 123 | 3 |
| Physics 71 | 4 | Chem 101.2 | 3 |
| PE | (2) | Chem 105 | 3 |
| NSTP[1] | (3) | Physics 71.1 | 1 |
| | | PE | (2) |
| | | NSTP[1] | (3) |

### THIRD YEAR

| 1st Semester (18 units) | | 2nd Semester (18 units) | |
|---|---|---|---|
| GE (AH 3) Fil 40* | 3 | GE (AH 5) Free Choice | 3 |
| GE (AH 4) Free Choice | 3 | GE (MST 1)Free Choice | 3 |
| Chem 145 | 3 | Chem 146 | 3 |
| Chem 145.1 | 1 | Chem 112 | 3 |
| Chem 153 | 3 | Chem 102.1 | 3 |
| Physics 72 | 4 | Chem 154 | 3 |
| Physics 72.1 | 1 | | |

### SUMMER

**3 units**

| | |
|---|---|
| Chem 197 | 3 |

### FOURTH YEAR

| 1st Semester (15-17 units) | | 2nd Semester (17-19 units) | |
|---|---|---|---|
| Chem 113 | 3 | GE (SSP 4) Free Choice | 3 |
| Chem 102.2 | 3 | GE (MST 2) STS | 3 |
| Chem 156 | 3 | GE (SSP 5) Free Choice | 3 |
| Chem 196 | 1 | Chem 200 | 2 |
| Chem 200 | 2 | PI 100 | 3 |
| Elective[2] | 3 (5) | Elective[2] | 3 (5) |

*[1] choice of CMT (may be taken starting first year) or CWTS (may be taken starting second year)*
*[2] two (2) course electives equivalent to a minimum of six (6) units, at least three (3) units of which are science electives*
** Kas 1 and Fil 40 satisfy the 6-unit Philippine Studies requirement*
*Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

## BACHELOR OF SCIENCE IN PHYSICS
**174-180 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

### FIRST YEAR

| 1st Semester (18 units) | | 2nd Semester (18 units) | |
|---|---|---|---|
| Ge (AH 1) Eng 10 | 3 | GE (AH 2) Comm 3 | 3 |
| GE (MST 1) Physics 10 | 3 | Physics 101 | 4 |
| Geol 11 | 3 | Physics 101.1 | 1 |
| Geol 11.1 | 1 | Math 54[1] | 5 |
| Math 53[1] | 5 | Chem 16 | 5 |
| Math 14[1] | 3 | PE | (2) |
| PE | (2) | | |

### SECOND YEAR

| 1st Semester (19 units) | | 2nd Semester (19 units) | |
|---|---|---|---|
| GE (SSP 1) Philo 1 | 3 | GE (SSP 2) Kas 1* | 3 |
| Physics 102 | 4 | Physics 103 | 4 |
| Physics 102.1 | 1 | Physics 103.1 | 1 |
| Physics 111 | 3 | Physics 112 | 3 |
| Math 55 | 3 | Math 121.1 | 3 |
| Chem 17 | 5 | Bio 11 | 5 |
| PE | (2) | PE | (2) |

### THIRD YEAR

| 1st Semester (17 units) | | 2nd Semester (17 units) | |
|---|---|---|---|
| GE (SSP 3) Free Choice | 3 | App Physics 155 | 4 |
| Physics 104 | 4 | App Physics 181 | 4 |
| Physics 104.1 | 1 | Physics 122 | 3 |
| Physics 113 | 3 | Physics 132 | 3 |
| Physics 121 | 3 | Physics 141 | 3 |
| Physics 131 | 3 | | |

### FOURTH YEAR

| 1st Semester (20 units) | | 2nd Semester (15-17 units) | |
|---|---|---|---|
| GE (AH 3) Fil 40* | 3 | GE (SSP 4) Free Choice | 3 |
| Physics 114 | 3 | Physics 151 | 3 |
| Physics 142 | 3 | Physics 180 | 3 |
| Physics 165 | 3 | Physics 192 | 3 |
| Physics 170 | 3 | Physics /App Physics Elective[2] | 3-5 |
| Physics 191 | 5 | NSTP | (3) |
| NSTP | (3) | | |

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

## BACHELOR OF SCIENCE IN PHYSICS
**174-180 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

### FIFTH YEAR

| 1st Semester 15-17 units | | 2nd Semester 16-18 units | |
|---|---|---|---|
| GE (MST 2) STS | 3 | GE (AH 5) Free Choice | 3 |
| GE (AH 4) Free Choice | 3 | GE (SSP 5) Free Choice | 3 |
| Physics 152 | 3 | Science/Math Elective | 3-5 |
| Physics /App Physics Elective[2] | 3-5 | Physics 196 | 1 |
| Physics 199 | 3 | Physics 200 | 3 |
| | | PI 100 | 3 |

*[1] Math 14 and Math 53 are to be taken together provided the student has passed the APE in Math 11. Otherwise the student must take Math 17 in the 1st year/1st semester (in place of Math 14 and Math 53); Math 53 in the 1st year/2nd semester (in place of Math 54); and Math 54 in the immediately following summer session.*

*[2] May be chosen from Physics 135, 161, 195 or App Physics courses.*

*3 May be chosen, upon the consent of the adviser, from courses in natural sciences or mathematics*

* Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement

*Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

## BACHELOR OF SCIENCE IN APPLIED PHYSICS (MATERIALS PHYSICS)
**176 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

### FIRST YEAR

| 1st Semester 18 units | | 2nd Semester 18 units | |
|---|---|---|---|
| Ge (AH 1) Eng 10 | 3 | GE (AH 2) Comm 3 | 3 |
| GE (MST 1) Physics 10 | 3 | Physics 101 | 4 |
| Geol 11 | 3 | Physics 101.1 | 1 |
| Geol 11.1 | 1 | Math 54[1] | 5 |
| Math 53[1] | 5 | Chem 16 | 5 |
| Math 14[1] | 3 | PE | (2) |
| PE | (2) | | |

### SECOND YEAR

| 1st Semester 19 units | | 2nd Semester 16 units | |
|---|---|---|---|
| GE (SSP 1) Philo 1 | 3 | Physics 103 | 4 |
| Physics 102 | 4 | Physics 103.1 | 1 |
| Physics 102.1 | 1 | Physics 112 | 3 |
| Physics 111 | 3 | Math 121.1 | 3 |
| Math 55 | 3 | Bio 11 | 5 |
| Chem 17 | 5 | PE | (2) |
| PE | (2) | | |

### THIRD YEAR

| 1st Semester 17 units | | 2nd Semester 17 units | |
|---|---|---|---|
| GE (SSP 2) Kas 1* | 3 | Physics 105 | 3 |
| Physics 104 | 4 | Physics 141 | 3 |
| Physics 104.1 | 1 | App Physics 155 | 4 |
| Physics 113 | 3 | App Physics 181 | 4 |
| Physics 121 | 3 | Physics 132 | 3 |
| Physics 131 | 3 | | |

### SUMMER

**5 units**

| | |
|---|---|
| Chem 28 | 3 |
| Chem 28.1 | 2 |

## BACHELOR OF SCIENCE IN APPLIED PHYSICS (MATERIALS PHYSICS)
**176 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

### FOURTH YEAR

| 1st Semester (20 units) | | 2nd Semester (15 units) | |
|---|---|---|---|
| Physics 142 | 3 | GE (AH 3) Free Choice[2] | 3 |
| Physics 191 | 5 | Physics 151 | 3 |
| App Physics 173 | 3 | Physics 192 | 3 |
| Chem 153 | 3 | App Physics 171 | 3 |
| Chem 112 | 3 | App Physics 175 | 3 |
| MetE 143 | 3 | NSTP | (3) |
| NSTP | (3) | | |

### FIFTH YEAR

| 1st Semester (15 units) | | 2nd Semester (16 units) | |
|---|---|---|---|
| GE (MST 2) STS | 3 | GE (AH 5) Fil 40 * | 3 |
| GE (AH 4) Free Choice | 3 | GE (SSP 4) Free Choice | 3 |
| GE (SSP 3) Free Choice | 3 | GE (SSP 5) Free Choice | 3 |
| App Physics 176 | 3 | Physics 196 | 1 |
| App Physics 199 | 3 | Applied Physics 200 | 3 |
| | | PI 100 | 3 |

*[1]Math 14 and Math 53 are to be taken together provided the student has passed the APE in Math 11. Otherwise the students must take Math 17 in the 1st year/ 1st semester (in place of Math 14 and Math 53); Math 53 in the 1st year/ 2nd semester (in place of Math 54); and Math 54 in the immediately following summer session*

*[2]Six (6) units of the GE courses must satisfy the Philippine Studies requirement,*

** Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement*

*Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

## BACHELOR OF SCIENCE IN APPLIED PHYSICS (INSTRUMENTATION PHYSICS)
**179 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

### FIRST YEAR

| 1st Semester (18 units) | | 2nd Semester (18 units) | |
|---|---|---|---|
| Ge (AH 1) Eng 10 | 3 | GE (AH 2) Comm 3 | 3 |
| GE (MST 1) Physics 10 | 3 | Physics 101 | 4 |
| Geol 11 | 3 | Physics 101.1 | 1 |
| Geol 11.1 | 1 | Math 54[1] | 5 |
| Math 53[1] | 5 | Chem 16 | 5 |
| Math 14[1] | 3 | PE | (2) |
| PE | (2) | | |

### SECOND YEAR

| 1st Semester (19 units) | | 2nd Semester (19 units) | |
|---|---|---|---|
| GE (SSP 1) Philo 1 | 3 | GE (SSP 2) Kas 1* | 3 |
| Physics 102 | 4 | Physics 103 | 4 |
| Physics 102.1 | 1 | Physics 103.1 | 1 |
| Physics 111 | 3 | Physics 112 | 3 |
| Math 55 | 3 | Math 121.1 | 3 |
| Chem 17 | 5 | Bio 11 | 5 |
| PE | (2) | PE | (2) |

### THIRD YEAR

| 1st Semester (17 units) | | 2nd Semester (20 units) | |
|---|---|---|---|
| GE (AH 3) Free Choice | 3 | GE (AH 4) Free Choice | 3 |
| Physics 104 | 4 | GE (SSP 3) Free Choice | 3 |
| Physics 104.1 | 1 | Applied Physics 155 | 4 |
| Physics 113 | 3 | Applied Physics 181 | 4 |
| Physics 121 | 3 | Physics 132 | 3 |
| Physics 131 | 3 | Physics 141 | 3 |

### FOURTH YEAR

| 1st Semester (19 units) | | 2nd Semester (16 units) | |
|---|---|---|---|
| Physics 165 | 3 | Physics 166 | 3 |
| Physics 191 | 5 | Physics 151 | 3 |
| App Physics 156 | 4 | Physics 192 | 3 |
| App Physics 173 | 3 | App Physics 183 | 3 |
| App Physics 182 | 4 | App Physics 185 | 4 |
| NSTP[2] | (3) | NSTP[2] | (3) |

**BACHELOR OF SCIENCE IN APPLIED PHYSICS (INSTRUMENTATION PHYSICS)**
**179 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

## FIFTH YEAR

| 1st Semester 17 units | | 2nd Semester 16 units | |
|---|---|---|---|
| GE (MST 2) STS | 3 | GE (AH 5) Fil 40* | 3 |
| Physics 161 | 3 | GE (SSP 4) Free Choice | 3 |
| App Physics 186 | 4 | GE (SSP 5) Free Choice | 3 |
| App Physics 187 | 4 | Physics 196 | 1 |
| App Physics 199 | 3 | App Physics 200 | 3 |
| | | PI 100 | 3 |

*[1] Math 14 and Math 53 are to be taken together provided the student has passed the APE in Math 11. Otherwise the students must take Math 17 in the 1st year/ 1st semester (in place of Math 14 and Math 53); Math 53 in the 1st year/ 2nd semester (in place of Math 54); and Math 54 in the immediately following summer session*

** Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement*

*[2]Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

**BACHELOR OF SCIENCE IN MOLECULAR BIOLOGY AND BIOTECHNOLOGY**
**160 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

## FIRST YEAR

| 1st Semester 18 units | | 2nd Semester 18 units | |
|---|---|---|---|
| GE (SSP 1) Kas 1* | 3 | GE (AH 2) Fil 40 | 3 |
| Ge (AH 1) Eng 10 | 3 | BIO 11 | 5 |
| Math 17 | 5 | Math 53 | 5 |
| Chem 16 | 5 | Chem 26 | 3 |
| MBB 10 | 2 | Chem 26.1 | 2 |
| PE | (2) | PE | (2) |

## SUMMER

**8 units**

| | |
|---|---|
| Math 54 | 5 |
| GE (SSP 2) Free Choice | 3 |

## SECOND YEAR

| 1st Semester 18 units | | 2nd Semester 20 units | |
|---|---|---|---|
| BIO 12 | 5 | Physics 72 | 4 |
| Math 55 | 3 | Physics 72.1 | 1 |
| Chem 31 | 3 | Chem 40 | 3 |
| Chem 31.1 | 2 | Chem 40.1 | 2 |
| Physics 71 | 4 | MBB 110 | 4 |
| Physics 71.1 | 1 | BIO 180 | 3 |
| PE | (2) | MBB 100 | 3 |
| NSTP | (3) | PE | (2) |
| | | NSTP | (3) |

## THIRD YEAR

| 1st Semester 21 units | | 2nd Semester 18 units | |
|---|---|---|---|
| GE (SSP 3) Free Choice | 3 | GE (AH 3) Comm 3 | 3 |
| GE (SSP 4) Philo 1 | 3 | MBB 121 | 3 |
| MBB 130 | 4 | MBB 194 | 1 |
| Geol 11 | 3 | MBB 150 | 3 |
| MBB 140 | 3 | MBB 190 | 3 |
| MBB 125 | 5 | MBB 141 | 5 |

## SUMMER

**6 units**

| | |
|---|---|
| GE (AH 4) Free Choice | 3 |
| GE (SSP 5) Free Choice | 3 |

**BACHELOR OF SCIENCE IN MOLECULAR BIOLOGY AND BIOTECHNOLOGY**
**160 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

## FOURTH YEAR

| 1st Semester 18 units | | 2nd Semester 15 units | |
|---|---|---|---|
| MBB 195 | 3 | GE (AH 5) Free Choice | 3 |
| MBB 142 | 5 | GE (MST 1) STS | 3 |
| MBB 180 | 5 | GE MST 2(Free Choice) | 3 |
| PI 100 | 3 | MBB 196 | 1 |
| MBB 200 | 2 | MBB 197 | 3 |
| | | MBB 200 | 2 |

*We strongly recommend the Arts and Humanities GE Course:English 30 (3u).*

**Kas 1 and Fil 40 satisfy the 6-unit Philippine Studies requirement*

*Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

**BACHELOR OF SCIENCE IN MATHEMATICS**
**142 units**

APPROVAL
122nd UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

## FIRST YEAR

| 1st Semester 17 units | | 2nd Semester 17 units | |
|---|---|---|---|
| GE (AH 1) Free Choice | 3 | GE (AH 2) Eng 10 | 3 |
| GE (SSP 1) Free Choice | 3 | GE (SSP 3) Free Choice | 3 |
| GE (SSP 2) Free Choice | 3 | GE[1] (MST 2) Free Choice | 3 |
| GE[1] (MST 1) Free Choice | 3 | Math 63 | 5 |
| Math 60 | 5 | CS 11 | 3 |
| PE | (2) | PE | (2) |

## SECOND YEAR

| 1st Semester 19 units | | 2nd Semester 19 units | |
|---|---|---|---|
| GE (AH 3) Free Choice | 3 | GE (SSP 4) Philo 1 | 3 |
| Math 64 | 5 | GE[1] (MST 3) STS | 3 |
| Stat 101 | 3 | Math 65 | 3 |
| Math 109 | 3 | Math 110.1 | 3 |
| Physics 71 | 4 | Physics 72 | 4 |
| Physics 71.1 | 1 | Math 140 | 3 |
| PE | (2) | PE | (2) |
| NSTP | (3) | NSTP | (3) |

## THIRD YEAR

| 1st Semester 18 units | | 2nd Semester 19 units | |
|---|---|---|---|
| GE (SSP 5) Kas 1* | 3 | GE (AH 4) Fil 40* | 3 |
| Math 110.2 | 3 | GE (AH 5) Comm 3 | 3 |
| Math 123.1 | 3 | Math 110.3 | 3 |
| Math 150.1 | 3 | Math 123.2 | 3 |
| Math 122 | 3 | Math 171 | 3 |
| Elective[5] | 3 | Math 196 | 1 |
| | | Math Elective[4] | 3 |

## FOURTH YEAR

| 1st Semester 18 units | | 2nd Semester 15 units | |
|---|---|---|---|
| PI 100 | 3 | GE[1] (MST 4) Free Choice | 3 |
| Math 128 | 3 | Math Elective[4] | 3 |
| Math 200 | 3 | Math Elective[4] | 3 |
| Foreign Lang I[2] | 3 | Elective[5] | 3 |
| Math Elective[4] | 3 | Foreign Lang II[2] | 3 |
| Geom Elective[3] | 3-5 | | |

*[1] GE (Mathematics, Science and Technology) domain. Must not be Math 1 or 2*
*[2] Six (6) units of Foreign Language course except English*
*[3] Math 146 or Math 147 or Math 148*
*[4] Any Math Elective (upon approval by adviser) including Math 146, 147/148*
*[5] To be approved by adviser*
** Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement*
*Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

**BACHELOR OF SCIENCE IN GEOLOGY**
**162-163 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

## FIRST YEAR

| 1st Semester 18 units | | 2nd Semester 18 units | |
|---|---|---|---|
| GE (SSP 1) Free Choice | 3 | GE (AH 2) Comm 3 | 3 |
| Ge (AH 1) Eng 10 | 3 | GE (SSP 3) Kas 1* | 3 |
| GE (SSP 2) | 3 | Chem 16 | 5 |
| Geol 11 | 3 | Math 53 | 5 |
| Geol 11.1 | 1 | ES 1 | 2 |
| Math 17 | 5 | PE | (2) |
| PE | (2) | NSTP | (3) |
| NSTP | (3) | | |

## SUMMER

**5 units**

| | |
|---|---|
| Chem 26 | 3 |
| Chem 26.1 | 2 |

## SECOND YEAR

| 1st Semester 19 units | | 2nd Semester 19 units | |
|---|---|---|---|
| Geol 40 | 4 | GE (SSP 4) Philo 1 | 3 |
| GE 11 | 2 | GE (MST 1) STS | 3 |
| Math 54 | 5 | Geol 50 | 4 |
| BIO 11 | 5 | Geol 70 | 1 |
| Elective [1,2] | 3 | Physics 71 | 4 |
| PE | (2) | Physics 71.1 | 1 |
| | | Math 55 | 3 |
| | | PE | (2) |

## THIRD YEAR

| 1st Semester 20 units | | 2nd Semester 18 units | |
|---|---|---|---|
| GE (AH 3) Fil 40* | 3 | Geol 120 | 4 |
| Geol 60 | 4 | Geol 130 | 4 |
| Geol 112 | 4 | Geol 150 | 5 |
| Geol 140 | 4 | Physics 73 | 4 |
| Physics 72 | 4 | Physics 73.1 | 1 |
| Physics 72.1 | 1 | | |

## SUMMER

**6 units**

| | |
|---|---|
| Geol 170 | 6 |

**BACHELOR OF SCIENCE IN GEOLOGY**
**162-163 units**

APPROVAL
120th Special UPD UC : 02 April 2012 | President AEPascual : 04 June 2012

## FOURTH YEAR

| 1st Semester 19 units | | 2nd Semester 20-21 units | |
|---|---|---|---|
| GE (AH 4) Free Choice | 3 | GE (AH 5) Free Choice | 3 |
| GE (MST 2) Free Choice | 3 | GE (SSP 5) Free Choice | 3 |
| Geol 105 | 3 | Geol 181 | 4 |
| Geol 122 | 4 | Geol 194 | 5 |
| Geol 175 | 3 | Geol 196 | 2 |
| PI 100 | 3 | Geology Elective[2] | 3/4 |

*[1] Elective recommended: Economics 11 (Introductory Economics); Stat 101 (Elementary Statistics); Chem 150 (Introduction to Physical Chemistry); Math 121.1 (Elementary Differential Equations).*

*[2] Geol 131 (Micropaleontology), Geol 171 (Mineral Data Analysis), Geol 172 (Introduction to Statistics), Geol 173 (Introduction to Earth Resource Project Economics), Geol 174 (Introduction to Earth Resource Project Evaluation), Geol 177 (Geology of the Philippines and Southeast Asia), MS 100 (Marine Science 100)*

*A Math, Science and Technology subject whose content is substantially covered in the required courses in the B.S. Geology curriculum may not be taken as a GE course.*

** Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement*

*Note: As a requirement for graduation, all students must take six (6) units in one of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci). These are offered by UPD.*

## DIPLOMA IN BIOLOGY
**34-35 units**

APPROVAL
117th UPD UC : 11 April 2011 | President EAPascual : 06 June 2011

| Required Courses 27 units | | Required Courses 7-8 units | |
|---|---|---|---|
| Bio 120 | 4 | Any two of the following: | |
| Bio 133 | 5 | Bio 121** | 4 |
| Bio 140 | 5 | Bio 122** | 4 |
| Bio 150 | 5 | Bio 123** | 3 |
| Bio 160 | 5 | | |
| Bio 191 | 3 | | |

***Any two of the three courses in Physiology*

## DIPLOMA IN CHEMISTRY
**30-32 units**

APPROVAL
26th UPD UC : 03 August 1991

| 1st Semester 15 units | | 2nd Semester 15-17 units | |
|---|---|---|---|
| Chem 34 | 3 | Chem 112 | 3 |
| Chem 34.1 | 2 | Chem 123.1 or | 2 |
| Chem 123 | 3 | Chem 125 | 4 |
| Chem 153 | 3 | Chem 145 | 3 |
| Chem 196 | 1 | Chem 154 | 3 |
| Chem 152 | 3 | Chem 252 | 2 |

## DIPLOMA IN MATHEMATICS
**30 units**

APPROVAL
26th UPD UC : 03 August 1991

| 1st Semester 15 units | | 2nd Semester 15 units | |
|---|---|---|---|
| Math 109 | 3 | Math 110.1 | 3 |
| Math 55 | 3 | Math 123.1 | 3 |
| Stat 101 | 3 | Math 128 | 3 |
| Math 114 | 3 | CS 11 | 3 |
| Math 117 | 3 | Math 197 | 3 |

## DIPLOMA IN METEOROLOGY
**24 units**

APPROVAL
6th UPD UC : 18 January 1986 | BOR Approval : 28 February 1986

| Core Courses 18 units | | Specialization courses 6 units | |
|---|---|---|---|
| Meteor 201 | 3 | Courses in Meteorology | 6 |
| Meteor 202 | 3 | | |
| Meteor 210 | 3 | | |
| Meteor 213 | 3 | | |
| Meteor 221 | 3 | | |
| Meteor 232 | 3 | | |

*List of Specialization courses*

| | |
|---|---|
| *Meteor 233* | *Meteor 297* |
| *Meteor 234* | *Meteor 321* |
| *Meteor 241* | *Meteor 331* |
| *Meteor 261* | *Meteor 341* |
| *Meteor 271* | *Meteor 399* |
| *Meteor 283* | |

*Course Requirements:*
*18 units course work*
*6 units special courses*

## DIPLOMA IN PHYSICS
**24 units**

APPROVAL
26th UPD UC : 03 August 1991

| Course work 24 units | |
|---|---|
| Physics 101 | 4 |
| Physics 101.1 | 1 |
| Physics 102 | 4 |
| Physics 102.1 | 1 |
| Physics 103 | 4 |
| Physics 103.1 | 1 |
| Physics 111 | 3 |
| Physics 112 | 3 |
| Math 121.1 | 3 |

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

## DIPLOMA IN ENVIRONMENTAL SCIENCE
**21 units**

APPROVAL
34th UPD UC : 05 March 1994 | BOR : 24 March 1994

| Core Courses 17 units | | Specialization Course 3 units | |
|---|---|---|---|
| Lecture Courses* | 15 | Specialization Courses*** | 3 |
| Field/Laboratory Course** | 2 | | |

| Seminar 1 unit | |
|---|---|
| Env Sci 296 | 1 |

**Lecture Courses*
*Env Sci 201- 3 units*
*Env Sci 202- 3 units*
*Env Sci 211- 3 units*
*Env Sci 212- 3 units*
*Env Sci 282- 3 units*

***Field/Laboratory Courses*
*Env Sci 225.1*
*Env Sci 226.1*
*Env Sci 232.1*
*Env Sci 263.1*
*Env Sci 265.1*
*Env Sci 271.1*

****Specialization Courses*
*Env Sci 221*
*Env Sci 227*
*Env Sci 228*
*Env Sci 233*
*Env Sci 241*
*Env Sci 262*
*Env Sci 265*
*Env Sci 271*
*Env Sci 297*
*Env Sci 299*
*Env Sci 399*

*Course Requirements:*
*17 units core course*
*3 units specialization courses*
*1 unit seminar*

## PROFESSIONAL MASTER'S IN APPLIED MATHEMATICS (ACTUARIAL SCIENCE) 34 units

APPROVAL
95th UPD UC : 19 April 2006

| Core Courses 6 units | | Other Required Courses 12 units | |
|---|---|---|---|
| Math 203 | 3 | Math 260 | 3 |
| Math 271.1 | 3 | Math 261 | 3 |
| | | Math 262.1 | 3 |
| | | Math 262.2 | 3 |

| Other Required Courses 12 units | | Other Required Courses 4 units | |
|---|---|---|---|
| Elective | 3 | Math 295 (Special Project) | 3 |
| Elective | 3 | Math 296 | 1 |
| Elective | 3 | | |
| Elective | 3 | | |

| Preliminary Examination | Qualifying Examination |
|---|---|
| Comprehensive Examination | Oral Examination |

*Course Requirements:*
*33 units course work (including Special Project)*
*1 unit seminar*
*Preliminary (comprehensive) examinations*
*Qualifying (oral) examinations*

## PROFESSIONAL MASTERS IN TROPICAL MARINE ECOSYSTEMS MANAGEMENT 35 units

APPROVAL
131st UPD UC: 21 April 2014 | BOR: 30 June 2014

**F I R S T Y E A R**

| Tri-Term 1 12 units | | Tri-Term 2 10 units | |
|---|---|---|---|
| Module 1 | | Module 3 | |
| TMEM 201 | 3 | TMEM 220 | 3 |
| TMEM 210 | 1 | TMEM 211 | 1 |
| Module 2 | | Module 4 | |
| TMEM 202 | 4 | TMEM 221 | 5 |
| TMEM 203 | 4 | TMEM 296* | 1 |
| Preliminary Exam | | | |

**F I R S T Y E A R**

| Tri-Term 1 10 units | | Tri-Term 2 3 units | |
|---|---|---|---|
| Module 5: TMEM 222 | 5 | Module 7: TMEM 297** | 3 |
| Module 6: TMEM 223 | 5 | | |

**S E C O N D Y E A R**

** Corresponding course code in UPLB is TMEM 299 (Graduate Seminar)*
***Corresponding course code in UPLB is TMEM 290*

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

## MASTER OF SCIENCE (APPLIED MATHEMATICS)
**Thesis Option 31 units**

APPROVAL
95th UPD UC : 19 April 2006

### Core Courses
**9 units**

| | |
|---|---|
| Math 211 | 3 |
| Math 220.1 | 3 |
| Math 271. 1 | 3 |

### Numerical Analysis of Differential Equation Track 15 units

| | |
|---|---|
| Math 221 | 3 |
| Math 271.2 | 3 |
| Any three (3) additional courses of the ff: Math 229, Math 228, Math 222, Math 224, Math 281, and other relevant courses upon the approval of the adviser | 9 |

### Mathematics of Finance Track
**15 units**

| | |
|---|---|
| Math 265 | 3 |
| Math 266 | 3 |
| Any three (3) additional courses of the ff: Math 288, Stat 226, Stat 225, Math 250, and other relevant courses upon the approval of the adviser | 9 |

### Optimization & Approximation Track 15 units

| | |
|---|---|
| Math 222 | 3 |
| Math 280 | 3 |
| Any three (3) additional courses of the ff: Math 288, Math 281, Math 221, Math 250, Math 271.2, and other relevant courses upon the approval of the adviser | 9 |

### Mathematics in Life & Physical Science Track 15 units

| | |
|---|---|
| Math 235 | 3 |
| Math 236 | 3 |
| Any three (3) additional courses of the ff: Math 221, Math 288, Math 271.2, Math 229, Math 250, and other relevant courses upon the approval of the adviser | 9 |

### Thesis/Seminar
**7 units**

| | |
|---|---|
| Thesis | 6 |
| Math 296 | 1 |

*Course Requirements:*
*24 units course work*
*1 unit seminar*
*6 units thesis*

## MASTER OF SCIENCE (APPLIED MATHEMATICS )
**Non-Thesis Option 34 units**

APPROVAL
95th UPD UC : 19 April 2006

### Core Courses
**9 units**

| | |
|---|---|
| Math 211 | 3 |
| Math 220.1 | 3 |
| Math 271. 1 | 3 |

### Numerical Analysis of Differential Equation Track 15 units

| | |
|---|---|
| Math 221 | 3 |
| Math 271.2 | 3 |
| Any three (3) additional courses of the ff: Math 229, Math 228, Math 222, Math 224, Math 281, and other relevant courses upon the approval of the adviser | 9 |

### Mathematics of Finance Track
**15 units**

| | |
|---|---|
| Math 265 | 3 |
| Math 266 | 3 |
| Any three (3) additional courses of the ff: Math 288, Stat 226, Stat 225, Math 250, and other relevant courses upon the approval of the adviser | 9 |

### Qualifying Examination

Oral Examination

### Optimization & Approximation Track 15 units

| | |
|---|---|
| Math 222 | 3 |
| Math 280 | 3 |
| Any three (3) additional courses of the ff: Math 288, Math 281, Math 221, Math 250, Math 271.2, and other relevant courses upon the approval of the adviser | 9 |

### Mathematics in Life & Physical Science Track 15 units

| | |
|---|---|
| Math 235 | 3 |
| Math 236 | 3 |
| Any three (3) additional courses of the ff: Math 221, Math 288, Math 271.2, Math 229, Math 250, and other relevant courses upon the approval of the adviser | 9 |

### Preliminary Examination

Comprehensive Examination

### Electives
**9 units**

| | |
|---|---|
| Electives | 9 |

### Seminar
**1 unit**

| | |
|---|---|
| Math 296 | 1 |

*Course Requirements:*
*33 units course work*
*1 unit seminar*
*Preliminary (Comprehensive) Examination*
*Qualifying (Oral) Examination*

## MASTER OF ARTS (MATHEMATICS)
**34 units**

APPROVAL
95th UPD UC : 19 April 2006

### Core Courses
**16 units**

| | |
|---|---|
| Math 201 | 3 |
| Math 202.1 | 3 |
| Math 205 | 3 |
| Math 204 | 3 |
| Math 203 | 3 |
| Math 296 | 1 |

### Core Courses
**18 units**

| | |
|---|---|
| Math 209.1 | 3 |
| Math 209.2 | 3 |
| Math 208 | 3 |
| Elective | 3 |
| Math 290 (Research) | 3 |
| Math 202.2 | 3 |

### Preliminary Examination

Comprehensive Examination

*Course Requirements:*
*33 units course work (including research paper)*
*1 unit seminar*
*Preliminary (Comprehensive) Examination*

## MASTER OF SCIENCE (BIOLOGY)
**33 units**

APPROVAL
117th UPD UC : 11 April 2011 | President AEPascual : 06 June 2011

### Core Courses
**15 units**

| | |
|---|---|
| Bio 220 | 3 |
| Bio 230 | 3 |
| Bio 240 | 3 |
| Bio 250 | 3 |
| Bio 260 | 3 |

### Required Courses
**3 units**

| | |
|---|---|
| Bio 296 (Seminar) | 1 |
| Bio 299 (Research) | 2 |

### Specialty Electives
**9 units**

Cell & Molecular Biology[1]
Developmental Biology[2]
Ecology & Taxonomy[3]
Genetics[4]
Physiology[5]

### Thesis
**6 units**

| | |
|---|---|
| Bio 300 | 6 |

*Course Requirements:*
*24 units course work*
*1 unit Seminar*
*2 units Research*
*6 units Thesis writing*

*Areas of Concentration: Special Elective choices*
*[1]**Cell & Molecular Biology***
*Bio 241, Bio 251, Bio 299, Microbio 212, Microbio 271, MBB 221, Chem 240, Chem 241, Chem 242, Chem 243, Chem 244, Chem 245, Chem 247*
*[2]**Developmental Biology***
*Plant Dev't Biology: Bio 232, Bio 234, Bio 221, Bio 241, Bio 281, Bio 299*
*Animal Dev't Biology: Bio 233, Bio 241, Bio 251, Bio 281, Bio 299, Bio 322*
*[3]**Ecology & Taxonomy***
*Bio 210, Bio 244, Bio 262, Bio 263, Bio 265, Bio 271, Bio 299, Microbio 271, MS 250*
*[4]**Genetics***
*Bio 241, Bio 242, Bio 243, Bio 244, Bio 281, Bio 299, Microbio 241, Chem 243, Chem 245, Chem 247, MBB 241*
*[5]**Physiology***
*Plant Physiology: Bio 221, Bio 224, Bio 232, Bio 241, Bio 281, Bio 299, Chem 240*
*Animal Physiology: Bio 224, Bio 233, Bio 241, Bio 251, Bio 281, Bio 299, Bio 322, Chem 240*

## MASTER OF SCIENCE (CHEMICAL EDUCATION)
**33-35 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

| Core Courses<br>17-19 units | | Education Courses/Special Problems<br>5 units | |
|---|---|---|---|
| Chem 211 | 3 | Chem 288 | (2) |
| Chem 220 or Chem 223 | 3 | Chem 289 | (2) |
| Chem 230 | 3 | Educ 380 | 2 |
| Chem 240 | 3 | Educ 381 | 3 |
| Chem 250 | 3 | | |
| Chem 252 | 2 | | |

| Electives<br>9 units | Seminar<br>2 units | |
|---|---|---|
| Any of the remaining graduate Chemistry course offerings or any relevant graduate courses in other disciplines (e.g. Physics, Mathematics, Biology, etc.) | Chem 290 | 2 |

| Preliminary Examination | Qualifying Examination |
|---|---|
| Comprehensive Examination | Oral Examination |

*Course Requirements:*
*33-35 units course work*
*2 units Seminar*
*Preliminary (Comprehensive) Examination*
*Qualifying (Oral) Examination*

## MASTER OF SCIENCE (CHEMISTRY)
***Thesis*** **32-34 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

| Core Courses**<br>15-17 units | | Electives/Cognates<br>9 units |
|---|---|---|
| Chem 211 | 3 | |
| Chem 220 or Chem 223 | 3 | |
| Chem 230 | 3 | |
| Chem 240 series | 3 | |
| Chem 250 | 3 | |

| Seminar<br>2 units | | Thesis<br>6 units | |
|---|---|---|---|
| Chem 290 series | 2 | Thesis | 6 |

***Chem 220 or Chem 223*

*Course Requirements:*
*24 units course work*
*2 units Seminar*
*6 units Thesis*

## MASTER OF SCIENCE IN CHEMISTRY
***Non-Thesis*** **35 units**

APPROVAL
55th UPD UC: 23 July 1997

### Core Courses
**26 units**

| | |
|---|---|
| Chem 211 | 3 |
| Chem 213 | 3 |
| Chem 220 | 3 |
| Chem 230 | 3 |
| Chem 237 | 3 |
| Chem 240 | 3 |
| Chem 250 | 3 |
| Chem 255 or Chem 257 | 3 |
| Chem 220.1 | 2 |

### Cognate Course
**7 units**

| | |
|---|---|
| Cognate Courses | 7 |

### Seminar
**2 units**

| | |
|---|---|
| Chem 290 series | 2 |

### Preliminary Examination

Comprehensive Examination

### Qualifying Examination

Oral Examination

*Course Requirements:*
*33 units course work*
*2 units Seminar*
*Preliminary (Comprehensive) Examination*
*Qualifying (Oral) Examination*

## MASTER OF SCIENCE (ENVIRONMENTAL SCIENCE)
***Thesis*** **31 units**

APPROVAL
34th UPD UC : 05 March 1994 | BOR : 24 March 1994

### Core Courses
**18 units**

| | |
|---|---|
| Lecture Courses* | 15 |
| Field/Laboratory Course** | 3 |

### Specialization Courses
**6 units**

| | |
|---|---|
| Specialization courses*** | 6 |

### Seminar
**1 unit**

| | |
|---|---|
| Env Sci 296 | 1 |

### Thesis
**6 unit**

| | |
|---|---|
| Env Sci 300 | 6 |

**Lecture Courses*

| | |
|---|---|
| *Env Sci 201-* | *3 units* |
| *Env Sci 202-* | *3 units* |
| *Env Sci 211-* | *3 units* |
| *Env Sci 212-* | *3 units* |
| *Env Sci 282-* | *3 units* |

***Field/Laboratory Courses*

| | |
|---|---|
| *Env Sci 225.1* | *1 unit* |
| *Env Sci 226.1* | *1 unit* |
| *Env Sci 232.1* | *1 unit* |
| *Env Sci 263.1* | *1 unit* |
| *Env Sci 265.1* | *1 unit* |
| *Env Sci 271.1* | *1 unit* |

****Specialization Courses*

*Env Sci 221*
*Env Sci 227*
*Env Sci 228*
*Env Sci 233*
*Env Sci 241*
*Env Sci 262*
*Env Sci 265*
*Env Sci 271*
*Env Sci 297*
*Env Sci 299*
*Env Sci 399*

*The following existing courses in the College of Science and other colleges may also be credited as specialization courses:*

*College of Science*

*Bio 260*
*Bio 262*
*Bio 263*
*Chem 203*
*Chem 203.1*
*Chem 224*
*Geo 217*
*Geo 274*
*Meteo 203*
*Meteo 213*
*Meteo 283*
*MS 226*
*MS 226.1*
*MS 250*
*MS 280*

*Other Colleges*

*Econ 275*
*Econ 276*
*Econ 296*
*EnE 201*
*EnE 211*
*EnE 212*
*Law 175*
*Planning 203*
*Planning 222*
*Planning 231*
*Soc Sci 366*
*Soc Sci 367*

*Course Requirements:*
*18 units core course*
*6 units specialization course*
*1 unit Seminar*
*6 units Thesis*

## MASTER OF SCIENCE (ENVIRONMENTAL SCIENCE)
***Non-Thesis*** **34 units**

APPROVAL
34th UPD UC: 5 March 1994 | BOR Approval : 24 March 1994

| Core Courses 18 | | Specialization Courses 15 units | |
|---|---|---|---|
| Lecture Courses* | 15 | Specialization Courses | 15 |
| Field/Laboratory Course** | 3 | | |

| Seminar 1 unit | | Preliminary Examination |
|---|---|---|
| Env Sci 296 | 1 | Comprehensive Examination |

**Qualifying Examination**

Oral Examination

**Lecture Courses*

| | |
|---|---|
| *Env Sci 201-* | *3 units* |
| *Env Sci 202-* | *3 units* |
| *Env Sci 211-* | *3 units* |
| *Env Sci 212-* | *3 units* |
| *Env Sci 282-* | *3 units* |

***Field/Laboratory Courses*

| | |
|---|---|
| *Env Sci 225.1* | *1 unit* |
| *Env Sci 226.1* | *1 unit* |
| *Env Sci 232.1* | *1 unit* |
| *Env Sci 263.1* | *1 unit* |
| *Env Sci 265.1* | *1 unit* |
| *Env Sci 271.1* | *1 unit* |

****Specialization Courses*

*Env Sci 221*
*Env Sci 227*
*Env Sci 228*
*Env Sci 233*
*Env Sci 241*
*Env Sci 262*
*Env Sci 265*
*Env Sci 271*
*Env Sci 297*
*Env Sci 299*
*Env Sci 399*

*The following existing courses in the College of Science and other colleges may also be credited as specialization courses:*

*College of Science*

*Bio 260*
*Bio 262*
*Bio 263*
*Chem 203*
*Chem 203.1*
*Chem 224*
*Geo 217*
*Geo 274*
*Meteo 203*
*Meteo 213*
*Meteo 283*
*MS 226*
*MS 226.1*
*MS 250*
*MS 280*

*Other Colleges*

*Econ 275*
*Econ 276*
*Econ 296*
*EnE 201*
*EnE 211*
*EnE 212*
*Law 175*
*Planning 203*
*Planning 222*
*Planning 231*
*Soc Sci 366*
*Soc Sci 367*

*Course Requirements:*
*18 units core course*
*15 units specialization course*
*1 unit Seminar*
*Preliminary Examination*
*Qualifying Examination*

## MASTER OF SCIENCE (GEOLOGY)
**32 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

| Core Courses 11 units | | Electives 13 units | |
|---|---|---|---|
| Geol 215 | 3 | Electives | 13 |
| Geol 250 | 4 | | |
| Geol 253 | 4 | | |

| Seminar 2 units | | Thesis 6 units | |
|---|---|---|---|
| Geol 296 | 2 | Thesis | 6 |

## MASTER OF SCIENCE (MARINE SCIENCE)
**31-34 units**

APPROVAL
77th UPD UC : 16 April 2002 | President FNemenzo: 09 May 2002

| Core Courses 9-12 units | Electives 12-15 units | |
|---|---|---|
| Marine Biology[1] | Electives | 12-15 |
| Physical Oceanography[2] | | |
| Marine Biotechnology[3] | | |

| Seminar 1 unit | | Thesis 6 units | |
|---|---|---|---|
| MS 396 | 1 | MS 300 | 6 |

*Areas of Concentration: Core Courses*

*[1] Marine Biology:*

| | |
|---|---|
| *MS 210* | *3 units* |
| *MS 220* | *3 units* |
| *MS 240* | *3 units* |

*[2] Physical Oceanography*

| | |
|---|---|
| *MS 210* | *3 units* |
| *MS 220* | *3 units* |
| *MS 230* | *3 units* |
| *MS 240* | *3 units* |

*[3] Marine Biotechnology*

| | |
|---|---|
| *MS 240* | *3 units* |
| *MS 210** | *3 units* |
| *MS 270* | *3 units* |
| *MS 272* | *3 units* |

** may be substitiuted by MS 210 and MS 220*

*Course Requirements:*
*24 units course work*
*1 unit Seminar*
*6 units Thesis*
*Submitted ISI or Thomson Reuters Publication*

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

**MASTER OF SCIENCE (MATERIALS SCIENCE AND ENGINEERING)**
***Thesis*** **31 units**

APPROVAL
28th UPD UC : 21 April 1992

| Core Courses 24 units | | Seminar 1 unit | |
|---|---|---|---|
| MSE 201 | 3 | MSE 296 | 1 |
| MSE 225 | 3 | | |
| MSE 231 | 3 | | |
| MSE 233 | 3 | | |
| MSE 241 | 3 | | |
| MSE 251 | 3 | | |
| MSE 211-219* | 6 | | |

| Thesis 6 unit | |
|---|---|
| MSE 300 | 6 |

**Lab Modules in MSE (MSE 211-MSE 219):*
*MSE 211 1 unit*
*MSE 212 1 unit*
*MSE 213 1 unit*
*MSE 214 1 unit*
*MSE 215 1 unit*
*MSE 216 2 units*
*MSE 217 1 unit*
*MSE 218 1 unit*
*MSE 219 1 unit*

*Course Requirements:*
*24 units course work*
*1 unit Seminar*
*6 units Thesis*

**MASTER OF SCIENCE (MATERIALS SCIENCE AND ENGINEERING)**
***Non-Thesis*** **37 units**

APPROVAL
28th UPD UC : 21 April 1992

| Core Courses 24 units | | Electives 12 units | |
|---|---|---|---|
| MSE 201 | 3 | Electives | 12 |
| MSE 225 | 3 | | |
| MSE 231 | 3 | | |
| MSE 233 | 3 | | |
| MSE 241 | 3 | | |
| MSE 251 | 3 | | |
| MSE 211-219* | 6 | | |

| Seminar 1 unit | | Preliminary Examination |
|---|---|---|
| MSE 296 | 1 | Comprehensive Examanination |

| Qualifying Examination |
|---|
| Oral Examination |

**Lab Modules in MSE (MSE 211-MSE 219):*
*MSE 211 1 unit*
*MSE 212 1 unit*
*MSE 213 1 unit*
*MSE 214 1 unit*
*MSE 215 1 unit*
*MSE 216 2 units*
*MSE 217 1 unit*
*MSE 218 1 unit*
*MSE 219 1 unit*

*Course Requirements:*
*36 units course work*
*1 unit Seminar*
*Preliminary (Comprehensive) Examination*
*Qualifying (Oral) Examination*

## MASTER OF SCIENCE (MATHEMATICS)
***Thesis*** **31 units**

APPROVAL
95th UPD UC : 19 April 2006 | President ERRoman : 26 April 2006

| Core Courses 21 units | | Elective 3 units | |
|---|---|---|---|
| Math 210.1 | 3 | Elective (courses in Mathematics and allied fields) | 3 |
| Math 220.1 | 3 | | |
| Math 228 | 3 | | |
| Math 242 | 3 | | |
| Math 210.2 | 3 | | |
| Math 211 | 3 | | |
| One (1) Geometry Course | 3 | | |

| Seminar 1 unit | | Thesis 6 units | |
|---|---|---|---|
| Math 296 | 1 | Math 300 | 6 |

*Course Requirements:*
*24 units course work*
*1 unit Seminar*
*6 units Thesis*

## MASTER OF SCIENCE (MATHEMATICS)
***Non-Thesis*** **34 units**

APPROVAL
95th UPD UC : 19 April 2006 | President ERRoman : 26 April 2006

| Core Courses 21 units | | Elective 12 units | |
|---|---|---|---|
| Math 210.1 | 3 | Elective (courses in Mathematics and allied fields) | 12 |
| Math 220.1 | 3 | | |
| Math 228 | 3 | | |
| Math 242 | 3 | | |
| Math 210.2 | 3 | | |
| Math 211 | 3 | | |
| One (1) Geometry Course | 3 | | |

| Seminar 1 unit | | Preliminary Examination |
|---|---|---|
| Math 296 | 1 | Comprehensive Examination |

| Qualifying Examination |
|---|
| Oral Examination |

*Course Requirements:*
*33 units course work*
*1 unit Seminar*
*Preliminary (Comprehensive) Examination*
*Qualifying (Oral) Examination*

## MASTER OF SCIENCE (METEOROLOGY)
***Thesis*** **31 units**

APPROVAL
140th UPD UC : 05 September 2016 | President AEPascual: 26 September 2016

### FIRST YEAR

| 1st Semester 11 units | | 2nd Semester 10 units | |
|---|---|---|---|
| Meteo 201 | 4 | Meteo 231 | 4 |
| Meteo 211 | 3 | Elective | 3 |
| Meteo 221 | 4 | Elective | 3 |

### SECOND YEAR

| 1st Semester 7 units | | 2nd Semester 3 units | |
|---|---|---|---|
| Elective | 3 | Meteo 300 | 3 |
| Meteor 296 | 1 | | |
| Meteo 300 | 3 | | |

*Note: The student can take at least three of the following electives within the area of specialization subject for approval of the adviser:*
*Weather- Meteo 204, 223, 225, 233, 234*
*Climate- Meteo 203, 204, 212, 213, 222*
*Environmental- Meteo 206, 213, 224, Envi Sci 212, Envi Sci 282*
*Other Electives- Meteo 205, 232, 297*

## MASTER OF SCIENCE (METEOROLOGY)
***Non-Thesis*** **34 units**

APPROVAL
10th UPD UC : 23 March 1987

| Core Courses 18 units | | Electives and Specialization courses 15 units | |
|---|---|---|---|
| Meteor 201 | 3 | Electives and Specialization courses in Meteorology* | 15 |
| Meteor 202 | 3 | | |
| Meteor 210 | 3 | | |
| Meteor 213 | 3 | | |
| Meteor 221 | 3 | | |
| Meteor 232 | 3 | | |

| Seminar 1 unit | | Preliminary Examination |
|---|---|---|
| Meteor 296 | 1 | Comprehensive Examination |

| Qualifying Examination |
|---|
| Oral Examination |

*Course Requirements:*
*18 units core course*
*15 units electives and specialization course*
*1 unit Seminar*
*Preliminary Examination*
*Qualifying Examination*

**Electives and Specialization courses:*
*Meteor 233*
*Meteor 234*
*Meteor 241*
*Meteor 261*
*Meteor 271*
*Meteor 283*
*Meteor 297*
*Meteor 321*
*Meteor 331*
*Meteor 341*
*Meteor 399*

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

**MASTER OF SCIENCE (MICROBIOLOGY)**
**33 units**

APPROVAL
117th UPD UC : 11 April 2011 | President EAPascual : 06 June 2011

| Core Courses 15 units | | Required Courses 3 units | |
|---|---|---|---|
| Microbio 211 | 3 | Microbio 296 | 1 |
| Microbio 221 | 3 | Microbio 299 | 2 |
| Microbio 241 | 3 | | |
| Microbio 261 | 3 | | |
| Bio 250 | 3 | | |

| Electives 9 units | | Thesis 6 units | |
|---|---|---|---|
| Electives* | 9 | Microbio 300 | 6 |

** Electives (9 units of the following):*
*Microbio 212, Microbio 251, Microbio 262, Microbio 271, Microbio 281, BIO 241, BIO 251, MBB 215, MBB 280, MS 242, MS 261, FS 216, FS 236, FS 326*

*Course Requirements:*
*24 units core course*
*1 unit Seminar*
*6 units Thesis*

**MASTER OF SCIENCE (MOLECULAR BIOLOGY AND BIOTECHNOLOGY)**
**35 units**

APPROVAL
118th UPD UC : 18 July 2011 | President AEPascual : 17 August 2011

| Core Courses 15 units | | Elective 9 units | |
|---|---|---|---|
| MBB 221 | 3 | Electives* | 9 |
| MBB 225 | 3 | | |
| MBB 230 | 3 | | |
| MBB 241 | 3 | | |
| MBB 280 | 3 | | |

| Seminar 1 unit | | Thesis 6 units | |
|---|---|---|---|
| MBB 296 | 1 | MBB 300 | 6 |

| Other Required Courses 4 units | |
|---|---|
| MBB 289 | 3 |
| MBB 294 | 1 |

** Electives (9 units of the following):*
*MBB Electives: MBB 215, MBB 222, MBB 242, MBB 260, MBB 310, MBB 315, MBB 325, MBB 340, MBB 350, MBB 380, MBB 390, MBB 397, MBB 398*
*Non-MBB Electives: Bio 242, Bio 221, Bio 224, Bio 322, ChE 202, ChE 292, Chem 240, Chem 241, Chem 242, Chem 243, Chem 244, Chem 245, Chem 250, Chem 257, Chem 349, MS 253, MS 270, MS 385, MS 397*

*Course Requirements:*
*24 units course work*
*1 unit Seminar*
*4 units Other required courses*
*6 units Thesis*

## MASTER OF SCIENCE (PHYSICS)
**36 units *(Thesis)*/ 39 units *(Non-Thesis)***

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

| Core Courses 18 units | | Electives 6/15 units | |
|---|---|---|---|
| Phys 221 | 3 | Electives (thesis option) | 6 |
| Phys 231 | 3 | Electives (non-thesis) | 15 |
| Phys 232 | 3 | | |
| Phys 241 | 3 | | |
| Phys 242 | 3 | | |
| Phys 251 | 3 | | |

| Seminar 1 unit | | Colloquium 2 units | |
|---|---|---|---|
| Phys 296 | 1 | Phys 290 | 2 |

| Thesis 6 units | | Teaching 3 units | |
|---|---|---|---|
| Phys 300 | 6 | Physics Teaching* | 3 |

*Course Requirements (thesis):*
*24 units course work*
*1 unit Seminar*
*2 units Colloquium*
*6 units Thesis*
*3 units of undergraduate Physics Teaching (for students who have no experience in physics teaching)*

*Course Requirements (non-thesis):*
*33 units course work*
*1 unit Seminar*
*2 units Colloquium*
*Comprehensive Examination*
*3 units of undergraduate Physics Teaching*

## MASTER OF ARTS (PHYSICS)
**45 units**

APPROVAL
282nd UC : 05 February 1983

### FIRST YEAR

| 1st Semester 13 units | | 2nd Semester 13 units | |
|---|---|---|---|
| Physics 202.1 | 3 | Physics 202.2 | 3 |
| Physics 203.1 | 3 | Physics 203.2 | 3 |
| Physics 204.1 | 4 | Physics 204.5 | 3 |
| EDSC 278 or Graduate course in the College of Education | 3 | Physics 208 | 4 |

### SECOND YEAR

| 1st Semester 10 units | | 2nd Semester 3 | |
|---|---|---|---|
| Physics 209.1 | 4 | Physics 207** | (1) |
| Physics 205 | 3 | STS | (3) |
| Physics 210.1* | (2) | Physics 210.2* | (3) |
| Physics Elective | 3 | Physics Elective | 3 |

### SUMMER

**MA Comprehensive Examination**

*Course Requirements:*
*39 units course work*
*1 unit Seminar***
*STS*
*5 units Practicum**
*Comprehensive Exam*

*Physics Elective Courses*

| | |
|---|---|
| *Physics 204.2* | *Physics 206.2* |
| *Physics 204.6* | *Physics 206.6* |
| *Physics 206.5* | *Physics 206.7* |
| *Physics 206.8* | *Physics 209.2* |

## DOCTOR OF PHILOSOPHY (BIOLOGY)
***with MS Degree*** **37 units**

APPROVAL
117th UPD UC : 11 April 2011 | President AEPascual : 06 June 2011

| Core Courses* 15 units | | Required Courses 3 units | |
|---|---|---|---|
| Cell Biology, Developmental Biology, Ecology and Taxonomy, Genetics, and Physiology[1] or Microbiology[2] | 15 | Bio 296- Seminar<br>Bio 399- Independent Doctoral Research in Biology | 1<br>2 |

| Specialty Electives** 22 unit | | Dissertation 12 units | |
|---|---|---|---|
| Area of Specialization<br>Research/Independent Doctoral Research<br>Free Electives | 12<br>4<br>6 | Bio 400 | 12 |

** Core Courses (15 units may be taken or audited in preparation for the preliminary examinations):*
*[1] Cell Biology, Developmental Biology, Ecology and Taxonomy, Genetics, and Physiology* *[2] Microbiology*

| | | | |
|---|---|---|---|
| *Bio 220* | *3 units* | *Microbio 211* | *3 units* |
| *Bio 230* | *3 units* | *Microbio 221* | *3 units* |
| *Bio 240* | *3 units* | *Microbio 241* | *3 units* |
| *Bio 250* | *3 units* | *Microbio 261* | *3 units* |
| *Bio 260* | *3 units* | *Bio 250* | *3 units* |

***Electives (12 units of specialization, 4 units Research/Independent Doctoral Research, 6 units free electives in any area):*
***Cell Biology**- Bio 397, Bio 299, Bio 399, Bio 241, Bio 251, Microbio 212, Microbio 271, MBB 221, Any of the following: Chem 240, Chem 241, Chem 242, Chem 243, Chem 244, Chem 245, Chem 247*
***Developmental Biology-** Bio 397, Bio 299, Bio 399; Plant Development Biology- Bio 232, Bio 234, Bio 221, Bio 241, Bio 281; Animal Developmeny Biology- Bio 233, Bio 241, Bio 251, Bio 281, Bio 322*
***Ecology and Taxonomy-** Bio 397, Bio 299, Bio 399, Bio 210, Bio 244, Bio 262, Bio 263, Bio 265, Bio 271, Microbio 271, MS 250*
***Genetics-**Bio 397, Bio 299, Bio 399, Bio 241, Bio 242, Bio 243, Bio 244, Bio 281, Microbio 241, Chem 243, Chem 245, Chem 247, MBB 241, MBB 340*
***Physiology-** Bio 397, Bio 299, Bio 399; Plant Physiology- Bio 221, Bio 224, Bio 232, Bio 241, Bio 281, Chem 240; Animal Physiology- Bio 224, Bio 233, Bio 241, Bio 251, Bio 281, Bio 322, Chem 240*
***Microbiology**- Bio 397, Bio 299, Bio 399, Microbio 212, Microbio 251, Microbio 262, Microbio 271, Microbio 281, Bio 241, Bio 251, MBB 215, MBB 280, MS 242, MS 261, FS 216, FS 236, FS 326*

*Course Requirements:*
*22 units course work*
*1 unit Seminar*
*2 units Independent Doctoral Research in Biology*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*

## DOCTOR OF PHILOSOPHY (BIOLOGY)
***with BS Degree*** **58 units**

APPROVAL
117th UPD UC : 11 April 2011 | President AEPascual : 06 June 2011

| Core Courses* 15 units | | Required Courses 3 units | |
|---|---|---|---|
| Cell Biology, Developmental Biology, Ecology and Taxonomy, Genetics, and Physiology[1] or Microbiology[2] | 15 | Bio 296- Seminar<br>Bio 399- Independent Doctoral Research in Biology | 1<br>2 |

| Elective** 28 unit | | Dissertation 12 units | |
|---|---|---|---|
| Area of Specialization<br>Research/Independent Doctoral Research<br>Free Electives | 15<br>4<br>9 | Bio 400 | 12 |

** Core Courses (15 units may be taken or audited in preparation for the preliminary examinations):*
*[1] Cell Biology, Developmental Biology, Ecology and Taxonomy, Genetics, and Physiology* *[2] Microbiology*

| | | | |
|---|---|---|---|
| *Bio 220* | *3 units* | *Microbio 211* | *3 units* |
| *Bio 230* | *3 units* | *Microbio 221* | *3 units* |
| *Bio 240* | *3 units* | *Microbio 241* | *3 units* |
| *Bio 250* | *3 units* | *Microbio 261* | *3 units* |
| *Bio 260* | *3 units* | *Bio 250* | *3 units* |

***Electives (12 units of specialization, 4 units Research/Independent Doctoral Research, 6 units free electives in any area):*
***Cell Biology**- Bio 397, Bio 299, Bio 399, Bio 241, Bio 251, Microbio 212, Microbio 271, MBB 221, Any of the following: Chem 240, Chem 241, Chem 242, Chem 243, Chem 244, Chem 245, Chem 247*
***Developmental Biology-** Bio 397, Bio 299, Bio 399; Plant Development Biology- Bio 232, Bio 234, Bio 221, Bio 241, Bio 281; Animal Developmeny Biology- Bio 233, Bio 241, Bio 251, Bio 281, Bio 322*
***Ecology and Taxonomy-** Bio 397, Bio 299, Bio 399, Bio 210, Bio 244, Bio 262, Bio 263, Bio 265, Bio 271, Microbio 271, MS 250*
***Genetics-**Bio 397, Bio 299, Bio 399, Bio 241, Bio 242, Bio 243, Bio 244, Bio 281, Microbio 241, Chem 243, Chem 245, Chem 247, MBB 241, MBB 340*
***Physiology-** Bio 397, Bio 299, Bio 399; Plant Physiology- Bio 221, Bio 224, Bio 232, Bio 241, Bio 281, Chem 240; Animal Physiology- Bio 224, Bio 233, Bio 241, Bio 251, Bio 281, Bio 322, Chem 240*
***Microbiology**- Bio 397, Bio 299, Bio 399, Microbio 212, Microbio 251, Microbio 262, Microbio 271, Microbio 281, Bio 241, Bio 251, MBB 215, MBB 280, MS 242, MS 261, FS 216, FS 236, FS 326*

*Course Requirements:*
*37 units course work*
*1 unit Seminar*
*2 units Independent Doctoral Research in Biology*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

## DOCTOR OF PHILOSOPHY IN BIOLOGY (Option 3)
**26 units**

APPROVAL
129th UPD UC : 02 December 2013 | BOR : 28 March 2014

### F I R S T Y E A R

| 1st Semester 4 units | | 2nd Semester 2 units | |
|---|---|---|---|
| BIO 397 | 3 | BIO 296/Micro 296 | 1 |
| BIO 296/Micro 296 | 1 | BIO 296/Micro 296 | 1 |

### S E C O N D Y E A R

| 1st Semester 4 units | | 2nd Semester 4 units | |
|---|---|---|---|
| BIO 395 | 4 | BIO 395 | 4 |

### T H I R D Y E A R

| 1st Semester 6 units | | 2nd Semester 6 units | |
|---|---|---|---|
| BIO 400 | 6 | BIO 400 | 6 |

*Graduation Requirements:*
*26 units Coursework*
*Qualifying exam*
*12 units Seminar and independent doctoral research*
*12 units PhD dissertation*
*Dissertation Proposal*
*Colloquium*
*Dissertation defense*
*2 Publications in a highly reputed journal (e.g. Thomson Reuters indexed) derived from the dissertation research*
*Oral presentation in international or national scientific conference*
*Bound manuscript*

## DOCTOR OF PHILOSOPHY (CHEMISTRY)
***with MS Degree*** **38 units**

APPROVAL
UPD-CS-IS and UNIVERSITY OF HOUSTON; BOR Approval : 20 September 2012

| Core Courses 17 units | | Cognate Courses 7 units | |
|---|---|---|---|
| Chem 220 | 3 | Cognates | 7 |
| Chem 220.1 | 2 | | |
| Chem 235 | 3 | | |
| Chem 240-series | 3 | | |
| Chem 255 or Chem 257 | 3 | | |
| Chem 212 or Chem 213 | 3 | | |

| Seminar 2 units | | Dissertation 12 units | |
|---|---|---|---|
| Chem 390 series | 2 | Chem 400 | 12 |

*Course Requirements:*
*24 units course work*
*2 units Seminar*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*

*Students may also opt to obtain a PhD from the University of Houston (UH) by fulfilling the other requirements of UH.*

## DOCTOR OF PHILOSOPHY (CHEMISTRY)
***with BS Degree*** **59 units**

APPROVAL
UPD-CS-IS and UNIVERSITY OF HOUSTON; BOR Approval : 20 September 2012

### Core Courses
**32 units**

| | |
|---|---|
| Chem 211 | 3 |
| Chem 212 or Chem 213 | 3 |
| Chem 223 | 3 |
| Chem 220 | 3 |
| Chem 220.1 | 2 |
| Chem 230 | 3 |
| Chem 235 | 3 |
| Chem 240 | 3 |
| Chem 240 series | 3 |
| Chem 250 | 3 |
| Chem 255 or Chem 257 | 3 |

### Cognate Courses
**13 units**

| | |
|---|---|
| Cognates | 13 |

### Seminar
**2 units**

| | |
|---|---|
| Chem 390 series | 2 |

### Dissertation
**12 units**

| | |
|---|---|
| Chem 400 | 12 |

*Course Requirements:*
*45 units course work*
*2 unit Seminar*
*12 units dissertation*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*

*Students may also opt to obtain a PhD from the University of Houston (UH) by fulfilling the other requirements of UH.*

## DOCTOR OF PHILOSOPHY (ENVIRONMENTAL SCIENCE)
*with BS Degree* **58 units**

APPROVAL
34th UPD UC : 05 March 1994 | BOR : 24 March 1994

### Core Courses
**21 units**

| | |
|---|---|
| Lecture Courses* | 15 |
| Field/Laboratory Course** | 6 |

### Specialization Courses
**24 units**

| | |
|---|---|
| Specialization Courses*** | 24 |

### Seminar
**1 unit**

| | |
|---|---|
| Env Sci 296 | 1 |

### Dissertation
**12 unit**

| | |
|---|---|
| Env Sci 400 | 12 |

### Comprehensive Examination

### Candidacy Examination

### Colloquium

**Lecture Courses*

| | |
|---|---|
| *Env Sci 201-* | *3 units* |
| *Env Sci 202-* | *3 units* |
| *Env Sci 211-* | *3 units* |
| *Env Sci 212-* | *3 units* |
| *Env Sci 282-* | *3 units* |

***Field/Laboratory Courses*
*Env Sci 225.1*
*Env Sci 226.1*
*Env Sci 232.1*
*Env Sci 263.1*
*Env Sci 265.1*
*Env Sci 271.1*

****Specialization Courses*

| | |
|---|---|
| *Env Sci 221* | *Env Sci 265* |
| *Env Sci 227* | *Env Sci 271* |
| *Env Sci 228* | *Env Sci 297* |
| *Env Sci 299* | *Env Sci 399* |
| *Env Sci 262* | |

*The following existimg courses in the College of Science and other colleges may also be credited as specialization courses:*

| *College of Science* | | *Other Colleges* | |
|---|---|---|---|
| *Bio 260* | *Meteo 203* | *Econ 275* | *Law 175* |
| *Bio 262* | *Meteo 213* | *Econ 276* | *Planning 203* |
| *Bio 263* | *Meteo 283* | *Econ 296* | *Planning 222* |
| *Chem 203* | *MS 226* | *EnE 201* | *Planning 231* |
| *Chem 203.1* | *MS 226.1* | *EnE 211* | *Soc Sci 366* |
| *Chem 224* | *MS 250* | *EnE 212* | *Soc Sci 367* |
| *Geo 217* | *MS 280* | | |
| *Geo 274* | | | |

*Course Requirements:*
*21 units core courses*
*24 units specialization courses*
*1 unit Seminar*
*12 units Dissertation*
*Comprehensive Examination*
*Candidacy Examination*
*Colloquium*

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

## DOCTOR OF PHILOSOPHY (ENVIRONMENTAL SCIENCE)
*with MS Env Sci Degree* **37 units**

APPROVAL
34th UPD UC : 05 March 1994 | BOR : 24 March 1994

| Core Courses 3 units | | Specialization Courses 21 units | |
|---|---|---|---|
| Lecture Courses* | 0 | Specialization Courses*** | 21 |
| Field/Laboratory Course** | 3 | | |

| Seminar 1 unit | | Dissertation 12 unit | |
|---|---|---|---|
| Env Sci 296 | 1 | Env Sci 400 | 12 |

**Comprehensive Examination**

**Candidacy Examination**

**Colloquium**

**Lecture Courses*

| | |
|---|---|
| *Env Sci 201-* | *3 units* |
| *Env Sci 202-* | *3 units* |
| *Env Sci 211-* | *3 units* |
| *Env Sci 212-* | *3 units* |
| *Env Sci 282-* | *3 units* |

***Field/Laboratory Courses*
*Env Sci 225.1*
*Env Sci 226.1*
*Env Sci 232.1*
*Env Sci 263.1*
*Env Sci 265.1*
*Env Sci 271.1*

****Specialization Courses*

| | |
|---|---|
| *Env Sci 221* | *Env Sci 265* |
| *Env Sci 227* | *Env Sci 271* |
| *Env Sci 228* | *Env Sci 297* |
| *Env Sci 262* | *Env Sci 299* |
| *Env Sci 399* | |

*The following existimg courses in the College of Science and other colleges may also be credited as specialization courses:*

*College of Science*

| | |
|---|---|
| *Bio 260* | *Meteo 203* |
| *Bio 262* | *Meteo 213* |
| *Bio 263* | *Meteo 283* |
| *Chem 203* | *MS 226* |
| *Chem 203.1* | *MS 226.1* |
| *Chem 224* | *MS 250* |
| *Geo 217* | *MS 280* |
| *Geo 274* | |

*Other Colleges*

| | |
|---|---|
| *Econ 275* | *Law 175* |
| *Econ 276* | *Planning 203* |
| *Econ 296* | *Planning 222* |
| *EnE 201* | *Planning 231* |
| *EnE 211* | *Soc Sci 366* |
| *EnE 212* | *Soc Sci 367* |

*Course Requirements:*
*3 units core courses*
*21 units specialization courses*
*1 unit Seminar*
*12 units Dissertation*
*Comprehensive Examination*
*Candidacy Examination*
*Colloquium*

## DOCTOR OF PHILOSOPHY (GEOLOGY)*
**38 units**

APPROVAL
10th UPD UC : 23 March 1987

| Core Courses | | Specialization/Elective Courses 24 units | |
|---|---|---|---|

| Seminar 2 units | | Dissertation 12 units | |
|---|---|---|---|
| Geology 296 | | Geology 400 | 12 |

**with MS Geol from UP NIGS*

*Course Requirements:*
*24 units course work*
*2 units Seminar*
*12 units Dissertation Writing*
*Preliminary Examinations*
*Candidancy Examination*
*Colloquium*

## DOCTOR OF PHILOSOPHY (GEOLOGY)*
**59 units**

APPROVAL
10th UPD UC : 23 March 1987

| Core Courses | Other Reqiured Courses |
|---|---|
| Geology 215 | Specialization Courses |
| Geology 250 | Cognates/Electives |
| Geology 253 | |

| Seminar 2 units | | Dissertation 12 units | |
|---|---|---|---|
| | | Geology 400 | 12 |

** with MS Geog from other Institutions*

*Course Requirements:*
*45 units course work*
*2 units Seminar*
*12 units Dissertation Writing*
*Preliminary Examinations*
*Candidancy Examination*
*Colloquium*

*Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)*

**DOCTOR OF PHILOSOPHY (MARINE SCIENCE)**
***with MS Degree**** **37-40 units**

APPROVAL
24th UPD UC : 23 March 1987

| Core Courses 12-15 units | | Elective 12 units | |
|---|---|---|---|
| Marine Biology & Marine Physical Sciences[1] Marine Biotechnology[2] | 12-15 | Electives | 12 |

| Seminar** 1+ unit/s | | Dissertation 12 units | |
|---|---|---|---|
| MS 396 | 1 + unit/s | MS 400 | 12 |

** PhD student who earned their MS Marine Science degree.*
*** Every PhD student shall complete one (1) seminar course every other year after 12 units of courses have been credited to his/her program of study.*

***Core Courses:***
*[1] Marine Biology & Marine Physical Sciences*
*MS 210 3 units*
*MS 220 3 units*
*MS 230 3 units*
*MS 240 3 units*

*[2] Marine Biotechnology*
*MS 240 3 units*
*MS 201 3 units*
*MS 270 3 units*
*MS 272 3 units*
***MS 201 may be substituted by MS 210 & MS 220***

*Course Requirements:*
*24-27 units Coursework*
*1+ unit/s Seminar*
*12 units Dissertation writing*
*Qualifying (Comprehensive) Examination*
*Candidancy Examination*
*Colloquium*
*Submission of bound copies of dissertation*
*At least one publication from dissertation research in a referred scienctific journal*

**DOCTOR OF PHILOSOPHY (MARINE SCIENCE)**
***with BS Degree*** **58-61 units**

APPROVAL
24th UPD UC : 23 March 1987

| Core Courses 12-15 units | | Elective 33 units | |
|---|---|---|---|
| Marine Biology & Marine Physical Sciences[1] Marine Biotechnology[2] | 12-15 | Electives | 33 |

| Seminar** 1+ unit/s | | Dissertation 12 units | |
|---|---|---|---|
| MS 396 | 1 + unit/s | MS 400 | 12 |

** PhD student who earned their MS Marine Science degree.*
*** Every PhD student shall complete one (1) seminar course every other year after 12 units of courses have been credited to his/her program of study.*

***Core Courses:***
*[1] Marine Biology & Marine Physical Sciences*
*MS 210 3 units*
*MS 220 3 units*
*MS 230 3 units*
*MS 240 3 units*

*[2] Marine Biotechnology*
*MS 240 3 units*
*MS 201 3 units*
*MS 270 3 units*
*MS 272 3 units*
***MS 201 may be substituted by MS 210 & MS 220***

*Course Requirements:*
*45-48 units Coursework*
*1+ unit/s Seminar*
*12 units Dissertation writing*
*Qualifying (Comprehensive) Examination*
*Candidancy Examination*
*Colloquium*
*Submission of bound copies of dissertation*
*At least one publication from dissertation research in a referred scienctific journal*

## DOCTOR OF PHILOSOPHY IN MARINE SCIENCE (Option 3)
**26 units**

APPROVAL
129th UPD UC : 02 December 2013 | BOR : 28 March 2014

### FIRST YEAR

| 1st Semester 4 units | | 2nd Semester 2 units | |
|---|---|---|---|
| MS 397 (Special Topics) | 3 | MS 396 (Seminar) | 1 |
| MS 396 (Seminar) | 1 | MS 396 (Seminar) | 1 |

### SECOND YEAR

| 1st Semester 4 units | | 2nd Semester 4 units | |
|---|---|---|---|
| MS 395 (Advanced Studies) | 4 | MS 395 (Advanced Studies) | 4 |

### THIRD YEAR

| 1st Semester 6 units | | 2nd Semester 6 units | |
|---|---|---|---|
| MS 400 (Dissertation) | 6 | MS 400 (Dissertation) | 6 |

*Graduation Requirements:*
*26 units Coursework*
*Candidacy Exam*
*Dissertation proposal defense*
*3 units Seminars*
*3 units MS 397*
*8 units MS 395*
*Colloquium*
*Oral presentation in national or international conference*
*Progress reports while enrolled in MS 400*
*2 ISI-listed journal publications*
*Dissertation defense*
*Bound dissertation manuscript*

## DOCTOR OF PHILOSOPHY (MATERIALS SCIENCE AND ENGINEERING)
***with MS Degree*** **37 units**

APPROVAL
24th UPD UC : 23 March 1987

| Specialization Courses 24 units | Seminar 1 unit |
|---|---|
| MSE 243, MSE 243.1, MSE 245, MSE 245.1, MSE 253, MSE 255, MSE 265, MSE 266, MSE 267, MSE 268, MSE 271, MSE 271.1, MSE 271.2, MSE 275, MSE 276, MSE 281, MSE 283, MSE 283.1, MSE 285, MSE 286, MSE 287, MSE 287.1, MSE 298 | MSE 296 1 |

| Dissertation 12 units | |
|---|---|
| MSE 400 | 12 |

*Course Requirements:*
*24 units Coursework*
*1 unit Seminar*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*

## DOCTOR OF PHILOSOPHY (MATERIALS SCIENCE AND ENGINEERING)
***with BS Degree*** **58 units**

APPROVAL
28th UPD UC : 21 April 1992

| Core Courses 24 units | | Special Courses 21 units | |
|---|---|---|---|
| MSE 201 | 3 | Special Courses | 21 |
| MSE 225 | 3 | | |
| MSE 231 | 3 | | |
| MSE 233 | 3 | | |
| MSE 241 | 3 | | |
| MSE 251 | 3 | | |
| MSE 211-219* | 6 | | |

| Seminar 1 unit | | Dissertation 12 unit | |
|---|---|---|---|
| MSE 296 | 1 | MSE 400 | 12 |

**Lab Modules in MSE (MSE 211-MSE 219)*
*MSE 211 1 unit*
*MSE 212 1 unit*
*MSE 213 1 unit*
*MSE 214 1 unit*
*MSE 215 1 unit*
*MSE 216 2 units*
*MSE 217 1 unit*
*MSE 218 1 unit*
*MSE 219 1 unit*

*Course Requirements:*
*45 units Coursework*
*1 unit Seminar*
*12 units Dissertation*
*Qualifying (Comprehensive) Examination*
*Candidancy Examination*
*Colloquium*
*Submission of bound copies of dissertation*

## DOCTOR OF PHILOSOPHY (MATHEMATICS)
***with MS Degree*** **43 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

| Core Courses 21 units | | Other Required Courses 9 units |
|---|---|---|
| Math 210.1 | 3 | One additional Analysis Course |
| Math 210.2 | 3 | One Geometry Course |
| Math 211 | 3 | One additional Geometry or Topology Course |
| Math 220.1 | 3 | |
| Math 220.2 | 3 | |
| Math 228 | 3 | |
| Math 242 | 3 | |

| Dissertation 12 units | | Seminar 1 unit | |
|---|---|---|---|
| Math 400 | 12 | Math 296 | 1 |

*Course Requirements:*
*30 units Coursework*
*1 unit Seminar*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*
*Submission of bound copies of dissertation*

## DOCTOR OF PHILOSOPHY (MATHEMATICS)
***with BS Degree*** **58 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

### Core Courses
**21 units**

| | |
|---|---|
| Math 210.1 | 3 |
| Math 210.2 | 3 |
| Math 211 | 3 |
| Math 220.1 | 3 |
| Math 220.2 | 3 |
| Math 228 | 3 |
| Math 242 | 3 |

### Other Required Courses
**9 units**

One additional Analysis Course
One Geometry Course
One additional Geometry or Topology Course

### Elective
**15 units**

| | |
|---|---|
| Electives* | 15 |

### Seminar
**1 unit**

| | |
|---|---|
| Math 296 | 1 |

### Dissertation
**12 units**

| | |
|---|---|
| MSE 400 | 12 |

** courses in Mathematics and allied fields, with at least twelve (12) of the fifteen (15) units chosen from advanced Mathematics courses.*

*Course Requirements:*
*30 units Coursework*
*1 unit Seminar*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*
*Submission of bound copies of dissertation*

## DOCTOR OF PHILOSOPHY (METEOROLOGY)
***with BS Degree*** **58 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

### Core Courses
**18 units**

| | |
|---|---|
| Meteor 201 | 3 |
| Meteor 202 | 3 |
| Meteor 210 | 3 |
| Meteor 213 | 3 |
| Meteor 221 | 3 |
| Meteor 232 | 3 |

### Specialization Courses
**27 units**

| | |
|---|---|
| Courses in Meteorology* | 27 |

### Seminar
**1 unit**

| | |
|---|---|
| Meteor 296 | 1 |

### Dissertation
**12 units**

| | |
|---|---|
| Meteor 400 | 12 |

### Comprehensive Examination

### Candidacy Examination

### Colloquium

**Specialization Courses/Courses in Meteorology*

| | |
|---|---|
| *Meteor 233* | *Meteor 297* |
| *Meteor 234* | *Meteor 321* |
| *Meteor 241* | *Meteor 331* |
| *Meteor 261* | *Meteor 341* |
| *Meteor 271* | *Meteor 399* |
| *Meteor 283* | |

*Course Requirements:*
*18 units core courses*
*27 units specialization courses*
*1 unit Seminar*
*12 units Dissertation*
*Comprehensive Examination*
*Candidacy Examination*
*Colloquium*

## DOCTOR OF PHILOSOPHY (METEOROLOGY)
*with MS (Meteorology) Degree* **37 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

### Specialization Courses
**24 units**

| | |
|---|---|
| Courses in Meteorology* | 24 |

### Seminar
**1 unit**

| | |
|---|---|
| Meteor 296 | 1 |

### Dissertation
**12 units**

| | |
|---|---|
| Meteor 400 | 12 |

### Comprehensive Examination

### Candidacy Examination

### Colloquium

**Specialization Courses/Courses in Meteorology:*

| | |
|---|---|
| *Meteor 233* | *Meteor 297* |
| *Meteor 234* | *Meteor 321* |
| *Meteor 241* | *Meteor 331* |
| *Meteor 261* | *Meteor 341* |
| *Meteor 271* | *Meteor 399* |
| *Meteor 283* | |

*Course Requirements:*
*24 units specialization courses*
*1 unit Seminar*
*12 units Dissertation*
*Comprehensive Examination*
*Candidacy Examination*
*Colloquium*

## DOCTOR OF PHILOSOPHY (METEOROLOGY)
*with MS Degree in other fields* **52 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

### Core Courses
**18 units**

| | |
|---|---|
| Meteor 201 | 3 |
| Meteor 202 | 3 |
| Meteor 210 | 3 |
| Meteor 213 | 3 |
| Meteor 221 | 3 |
| Meteor 232 | 3 |

### Specialization Courses
**21**

| | |
|---|---|
| Courses in Meteorology* | 21 |

### Seminar
**1 unit**

| | |
|---|---|
| Meteor 296 | 1 |

### Dissertation
**12 units**

| | |
|---|---|
| Meteor 400 | 12 |

### Comprehensive Examination

### Candidacy Examination

### Colloquium

**Specialization Courses/Courses in Meteorology:*

| | |
|---|---|
| *Meteor 233* | *Meteor 297* |
| *Meteor 234* | *Meteor 321* |
| *Meteor 241* | *Meteor 331* |
| *Meteor 261* | *Meteor 341* |
| *Meteor 271* | *Meteor 399* |
| *Meteor 283* | |

*Course Requirements:*
*18 units core courses*
*27 units specialization courses*
*1 unit Seminar*
*12 units Dissertation*
*Comprehensive Examination*
*Candidacy Examination*
*Colloquium*

## DOCTOR OF PHILOSOPHY (MOLECULAR BIOLOGY and BIOTECHNOLOGY) *with BS Degree* 62 units

APPROVAL
118th UPD UC : 18 July 2011 | President AEPascual : 17 August 2011

| Core Courses 15 units | | Elective* 30 units |
|---|---|---|
| MBB 221 | 3 | Specialty Electives (MBB) |
| MBB 225 | 3 | Other Electives |
| MBB 230 | 3 | |
| MBB 241 | 3 | |
| MBB 280 | 3 | |

| Dissertation 12 units | | Seminar 1 unit | |
|---|---|---|---|
| MBB 400 | 12 | MBB 296 | 1 |

| Other Required Courses 4 units | |
|---|---|
| MBB 289 | 3 |
| MBB 294 | 1 |

** Electives:*
*MBB Electives: MBB 215, MBB 222, MBB 242, MBB 260, MBB 310, MBB 315, MBB 325, MBB 340, MBB 350, MBB 380, MBB 390, MBB 397, MBB 398*
*Non-MBB Electives: Bio 242, Bio 221, Bio 224, Bio 322, ChE 202, ChE 292, Chem 240, Chem 241, Chem 242, Chem 243, Chem 244, Chem 245, Chem 250, Chem 257, Chem 349, MS 253, MS 270, MS 385, MS 397*

*Course Requirements:*
*45 units Coursework*
*1 unit Seminar*
*12 units Dissertation Writing*
*4 units Other Required Courses*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*
*Submission of bound copies of dissertation*

## DOCTOR OF PHILOSOPHY (MOLECULAR BIOLOGY AND BIOTECHNOLOGY) *with MS Degree* 41 units

APPROVAL
118th UPD UC : 18 July 2011 | President AEPascual : 17 August 2011

| Core Courses* 15 units | | Electives** 24 units | |
|---|---|---|---|
| MBB 221 | 3 | Specialty Electives (MBB) | 24 |
| MBB 225 | 3 | Other Electives | |
| MBB 230 | 3 | | |
| MBB 241 | 3 | | |
| MBB 280 | 3 | | |

| Dissertation 12 units | | Seminar 1 unit | |
|---|---|---|---|
| MBB 400 | 12 | MBB 296 | 1 |

| Other Required Courses 4 units | |
|---|---|
| MBB 289 | 3 |
| MBB 294 | 1 |

** Core Courses (15 units may be taken or audited in preparation for the preliminary exams)*
*** Electives:*
*MBB Electives: MBB 215, MBB 222, MBB 242, MBB 260, MBB 310, MBB 315, MBB 325, MBB 340, MBB 350, MBB 380, MBB 390, MBB 397, MBB 398*
*Non-MBB Electives: Bio 242, Bio 221, Bio 224, Bio 322, ChE 202, ChE 292, Chem 240, Chem 241, Chem 242, Chem 243, Chem 244, Chem 245, Chem 250, Chem 257, Chem 349, MS 253, MS 270, MS 385, MS 397*

*Course Requirements:*
*24 units Coursework*
*1 unit Seminar*
*4 units Other Required Courses*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidancy Examination*
*Colloquium*
*Submission of bound copies of dissertation*

## DOCTOR OF PHILOSOPHY (PHYSICS)
***with MS Degree*** **39 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

| Specialty Courses 9 units | |
|---|---|
| Specialty Courses | 6 |
| Advanced Specialty Course | 3 |

| Electives 15 units | |
|---|---|
| Breadth Electives | 12 |
| Methods Elective | 3 |

| Seminar 1 unit | |
|---|---|
| Phys 296 | 1 |

| Colloquium 2 units | |
|---|---|
| Phys 290 | 2 |

| Dissertation 12 unit | |
|---|---|
| Physics 400 | 12 |

*Course Requirements:*
*24 units Course work*
*1 unit Seminar*
*2 units Colloquium*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidacy Examination*
*Colloquium (Presentation)*
*Submission of bound copies of dissertation*
*3 units of undergraduate Physics Teaching*

## DOCTOR OF PHILOSOPHY (PHYSICS)
***with BS Degree*** **60 units**

APPROVAL
10th UPD UC : 23 March 1987 | President Approval: 1 April 1987

| Core Courses 18 units | |
|---|---|
| Phys 221 | 3 |
| Phys 231 | 3 |
| Phys 232 | 3 |
| Phys 241 | 3 |
| Phys 242 | 3 |
| Phys 251 | 3 |

| Specialty Courses 9 units | |
|---|---|
| Specialty Courses | 6 |
| Advanced Specialty Course | 3 |

| Electives 18 units | |
|---|---|
| Breadth Electives | 12 |
| General Elective | 3 |
| Methods Elective | 3 |

| Seminar 1 unit | |
|---|---|
| Phys 296 | 1 |

| Colloquium 2 units | |
|---|---|
| Phys 290 | 2 |

| Dissertation 12 unit | |
|---|---|
| Physics 400 | 12 |

*Course Requirements:*
*45 units Course work*
*1 unit Seminar*
*2 units Colloquium*
*12 units Dissertation Writing*
*Qualifying (Comprehensive) Examinations*
*Candidacy Examination*
*Colloquium (Presentation)*
*Submission of bound copies of dissertation*
*3 units of undergraduate Physics Teaching*

## COURSE OFFERINGS

### INTERDEPARTMENTAL

### GENERAL EDUCATION COURSES

**Natural Science (Nat Sci)**

**1**[a] **Foundations of Natural Science 1.** Fundamental concepts, principles and theories of physics and chemistry. 3 u.

**2**[b] **Foundations of Natural Science 2.** Fundamental concepts, principles, and theories of earth and life sciences. 3 u.

**Science, Technology and Society (STS)**

**Science, Technology and Society.** The study of how science and technology shape and are shaped by society, its culture, values and institutions. An exploration of the ways science and other disciplines interact. 3 u.

**Environmental Issues.** 3 u.; may be taken in lieu of Nat Sci 2**.**

### INSTITUTE OF BIOLOGY

### GENERAL EDUCATION COURSE

**Biology (BIO)**

**1**[c] **Contemporary Topics in Biology.** Recent developments in biology pertinent to concerns about the nature of life, health and related social issues. 3 u.

### UNDERGRADUATE

**Biology (BIO)**

**11**[d] **Fundamentals of Biology I.** The fundamentals of biology from the molecular and cellular levels up to organ systems of organization. Prereq: Chem 16/equiv. 9 h. (3 lec, 6 lab) 5 u.

**12**[d] **Fundamentals of Biology II.** The fundamentals of biology including reproductive and development genetics, systematics, evolution and ecology. Prereq: BIO 11. 9 h. (3 lec, 6 lab) 5 u.

**101** **Plant Morphoanatomy.** Morphology and anatomy of the vascular plants. Prereq: BIO 12. 5 h. (2 lec, 3 lab) 3 u.

**102** **Comparative Vertebrate Anatomy.** Functional and comparative morphology of the various classes of vertebrates from an evolutionary perspective. Prereq: BIO 12. 9 h. (3 lec, 6 lab) 5 u.

**111** **Phycology. Taxonomy, morphology and phylogeny of algae.** Prereq: BIO 12/equiv. 8 h. (2 lec, 6 lab) 4 u.

**112** **Mycology.** Taxonomy, morphology and ecology of the fungi and lichens. Prereq: BIO 12. 8 h. (2 class, 6 lab) 4 u.

**113** **Fundamentals of Virology.** Viral taxonomy, structure, replication, and pathogenesis, virus-host interactions. Prereq: BIO 120, BIO 150. (3h lec). 3 u.

**114** **Mosses, Hepatics and Ferns.** Evolutionary morphology, classification and ecology of mosses, hepatics and ferns . Prereq: BIO 12. 8 h. (2 lec, 6 lab) 4 u.

**115** **Taxonomy of Angiosperms.** Introduction to the principles and methods of the description, identification, nomenclature and classification of angiosperms (flowering plants); survey of selected flowering plant families with a discussion on phylogenetic relationships. Prereq: BIO 12. 8 h. (2 lec, 6 lab) 4 u.

**116** **Invertebrate Biology.** Taxonomy, phylogeny, systematics based on molecular data, and selected aspects of physiology, reproduction, and ecology of invertebrates. Prereq: BIO 12. (2h lec, 6h lab). 4 u.

**117** **Vertebrate Biology.** Biology of amphibians, reptiles, birds, and mammals. Prereq: BIO 102. (2h lec, 6h lab). 4 u.

**118** **Insect Biology.** Structure, function, development, taxonomy and distribution of insects and allied forms. Methods of collection for study. Prereq: BIO 12. 8 h. (2h lec, 6h lab). 4 u.

**119** **Fish Biology.** Morphology, physiology, ecology, behavior, genetics and taxonomy of fish. Prereq: BIO 102. 8 h. (2h lec, 6h lab) 4 u.

**120** **General Microbiology.** Biology of microorganisms and introduction to applied microbiology. Prereq: BIO 12; Coreq: Chem 40, 40.1. 8 h. (2 lec, 6 lab) 4 u.

**121** **Plant Physiology.** Fundamental aspects of plant vital functions, including nutrition, photosynthesis, absorption and translocation of materials, growth and development. Prereq: BIO 101, Chem 40, 40.1. 8 h. (2 lec, 6 lab) 4 u.

**122** **Animal Physiology.** Principles of animal functions with emphasis on physiological regulations and adaptations. Prereq: BIO 102, Chem 40, 40.1. 8 h. (2 lec, 6 lab) 4 u.

**123** **Fundamentals of Microbial Physiology.** Composition and structure of microbial cells; regulation of biochemical activities associated with cellular metabolism. Prereq: BIO 120. (2h lec, 3h lab). 3 u.

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[a] *Substitute Courses: Chem 16, Physics 71/their equivs. Math, Science and Technology domain.*

[b] *Can be substantially substituted. A set of courses in the major field of students in natural science curricula may be substituted for the recommended prescribed General Education Course (e.g. Nat Sci 1 and 2). Math, Science and Technology domain.*

[c] *Math, Science and Techology domain.*

[d] *This is part of a two-semester course.*

**125** **Medical Microbiology.** Survey of various microorganisms associated with human health and description of host-pathogen interactions. Prereq: Bio 120. (2h lec, 3h lab). 3 u.

**133** **Developmental Biology.** Developmental biology of selected plants and animals with emphasis on basic similarities in mechanisms that regulate plant and animal development occurring at the molecular level and in the generation of patterns; fundamental differences in modes of development between plants and animals. Prereq: Bio 101, Bio 102. (3h lec, 6h lab). 5 u.

**134** **General Animal Histology.** Microscopic structures and functional significance of animal tissues using an organ system approach. Prereq: BIO 102. 5 h. (2 class, 3 lab) 3 u.

**140** **Fundamentals of Genetics.** Genetics from Mendel to the present; basic principles, concepts and mechanisms of genetics and modern developments in the field with their theoretical and practical implications. Prereq: BIO 12, Chem 40, Chem 40.1, BIO 180. 9 h. (3h lec, 6h lab). 5 u.

**141** **Fundamentals of Microbial Genetics.** Structure, expression, and applications of exchange of genetic materials in bacteria, fungi, and bacteriophages. Prereq: BIO 120. (2lec, 3h lab). 3 u.

**150** **Fundamentals of Cell and Molecular Biology.** Study of living processes at the cellular and molecular levels of organization. Prereq: BIO 12, Chem 40, 40.1. 9 h. (3 lec, 6 lab) 5 u.

**151** **Introduction to Immunobiology.** Structure and function of the immune system; antigen-antibody interactions; genetic control of the immune system; basic immunological technique. Prereq: BIO 120, BIO 140, BIO 150. 8 h. (2h lec, 6h lab) 4 u.

**160** **Fundamentals of Ecology.** Principles and concepts pertaining to ecosystem structure and function, properties and interactions of populations, species adaptations and environmental influences, and oganization and dynamics of terrestrial and aquatic communities. Prereq: SS. 8 h. (3h lec, 6h lab) 5 u.

**161** **Field Biology.** Plants and animals in their natural environment; their preparation for laboratory study. Prereq: SS. 5 u.

**162** **Limnology.** Physical, chemical and biological aspects of freshwater habitats. Prereq: SS. 8 h. (2h lec, 6h lab) 4 u.

**163** **Fundamentals of Microbial Ecology.** Ecology and evolution of microorganisms, microbial interrelationships and biogeochemical cycles. Prereq: BIO 120. (2h lec, 3h lab). 3 u.

**164** **Biodiversity and Conservation Biology.** Study of species assemblages, their distribution and ecosystems with particular reference to mechanisms of change and human impact. Prereq: Junior Standing or COI. (3h lec). 3 u.

**165** **Biogeography.** Ecological and historical aspects of spatial distribution of plants and animals. Prereq: Junior Standing or COI. 3 u.

**170** **Animal Behavior.** Causes and basis of comparative animal behavior with emphasis on the adaptive survival and reproductive mechanisms. Prereq: BIO 116, BIO 122. 3 u.

**171** **General Parasitology.** Biology, morphology, life cycles, mechanisms of pathogenesis, epidemiology, and control of parasites including experiments involving cellular and molecular mechanisms of host-parasite interactions. Prereq: BIO 102, 116. 8 h. (2h lec, 6h lab). 4 u.

**180** **Statistical Methods in Biology.** Applications of basic statistics in the biological sciences. Prereq: Math 17. 3 u.

**191** **Systematics and Evolution.** Introduction to biological systematics and evolution covering the fundamental theory, methods, and purposes of biosystematics and the events and processes of organic evolution. Junior Standing or COI. (3h lec). 3 u.

**196** **Undergraduate Seminar.** Prereq: SS. 1 u.; may be taken twice.

**200A** **Undergraduate Thesis I.** Prereq: SS. 2 u.

**200B** **Undergraduate Thesis II.** Prereq: BIO 200A. 2 u.

**GRADUATE**

**Biology (BIO)**

**210** **Advanced Systematics.** Advanced principles and methods in phylogenetic systematics. Prereq: Bio 191/COI. 5 h. (2 lec, 3 lab) 3 u.

**220** **Chemical Physiology.** Integrative approach to plant and animal physiology, with focus on the molecular and cellular bases. Prereq: BIO 121/122/COI. 5 h. (2 lec, 3 lab) 3 u.

**221** **Advanced Plant Physiology.** Advanced concepts of plant physiology; plant-water relations, inorganic nutrition, metabolic systems hormonal regulation and environmental control of growth and development, and plant movements. Prereq: BIO 121/equiv. (2h lec, 3h lab). 3 u.

**224** **Stress Physiology.** Physiological responses of plants and animals to environmental stress. Prereq: BIO 121, 122/equivs. 5 h. (2 lec, 3 lab) 3 u.

**230** **Differentiation in Embryonic Systems.** Concepts and mechanisms underlying specialization of cells during early development. Prereq: BIO 133/equiv/COI. 3 u.

**232** **Advances in Plant Developmental Biology.** Current topics on key areas of plant development; i.e. embryonic development,

meristem activity during post-embryonic development, cytological features of developing structures, and genetic control of plant development. Prereq: BIO 133/equiv. (2h lec, 3h lab). 3 u.

**233** **Advances in Animal Developmental Biology.** Current concepts on the underlying principles of animal development. Prereq: BIO 133/equiv. 5h. (2h lec, 3h lab). 3 u.

**234** **Developmental Morphology of Vascular Plants.** Developmental morphology and anatomy of vascular plants at different stages of their vegetative and reproductive growth. Prereq: BIO 133/equiv. 5 h. (2 lec, 3 lab) 3 u.

**240** **Advanced Genetics.** Advanced principles and methods of genetics. Prereq: BIO 140/equiv. 5 h. (2 lec, 3 lab) 3 u.

**241** **Advanced Molecular Genetics.** The principles of heredity elucidated at the molecular level. Prereq: COI. 5 h. (2 lec, 3 lab) 3 u.

**242** **Cytogenetics.** Cytology and genetics of induced chromosomal aberrations. Prereq: BIO 240/COI. 5 h. (2 lec, 3 lab) 3 u.

**243** **Population Genetics.** Analysis of gene frequencies and their alteration in a population. Prereq: BIO 140/COI. 5 h. (2 lec, 3 lab) 3 u.

**244** **Advanced Evolutionary Genetics.** Mechanisms of evolution using advanced principles of molecular and population genetics. Prereq: BIO 240/equiv. (3h lec). 3 u.

**250** **Advanced Cell and Molecular Biology.** Advanced study on current topics in cell and molecular biology. Prereq: BIO 150. 3 u.

**251** **Advanced Immunobiology.** Advanced concepts and methods in immunobiology. Prereq: BIO 151/ equiv. 5 h. (2 lec, 3 lab) 3 u.

**260** **Advanced Ecology.** Principles and concepts underlying ecosystem structure and function in natural environments. Prereq: BIO 160/COI. 5 h. (2 lec, 3 lab) 3 u.

**262** **Freshwater Ecology.** Composition and dynamics of freshwater communities. Prereq: BIO 160/COI. 5 h. (2 lec, 3 lab) 3 u.

**263** **Terrestrial Ecology.** Composition and dynamics of terrestrial communities. Prereq: BIO 160/COI. 5 h. (2 lec, 3 lab) 3 u.

**265** **Advanced Biogeography.** Current concepts on plant and animal distribution. Prereq: BIO 160/equiv. 3 u.

**271** **Advanced Parasitology.** Current trends and concepts in host-parasite relationships. Prereq: BIO 171/equiv. 5 h. (2 lec, 3 lab) 3 u.

**280** **Protozoology.** Biology of representative protozoa. Prereq: BIO 116, 116.1. 5 h. (2 lec, 3 lab) 3 u.

**281** **Experimental Design and Statistical Analysis.** Design and analysis of experiments and application of nonparametric and multivariate methods in the life sciences. Prereq: Bio 180/equiv. 3 u.

**296** **Seminar.** Prereq: Completion of 12 u of graduate courses. 1 u.; may be taken twice.

**299** **Research in Biology.** Conceptualization, conduct of actual research and preparation of scientific manuscript on a biological research problem. Prereq: Completion of 12 u of graduate courses. (6h lab). 2 u (may be taken thrice provided that the research topics are not the same; topic(s) to be specified for record purposes).

**300** **M.S. Thesis.** Prereq: Completion of course requirements. 6 u.

**322** **Advanced Animal Physiology.** Advanced concepts of animal physiology; analyses of adaptive functions and mechanisms in various animal groups. Prereq: BIO 122/equiv. 5 h.(2h lec, 3h lab). 3 u.

**395** **Advanced Studies in Biology.** Conduct of actual research, preparation of scientific manuscript on an advanced research problem in Biology, and submission of manuscript in a highly reputed journal (e.g. Thomson Reuters indexed) journal for peer review. 12 h (lab). May be taken twice provided that the research topics are not the same; topic(s) to be specified for record purposes. 4 u.

**397** **Current Topics in Biology.** Discussions on current and emerging issues in the biological sciences. Prereq: COI. 3 u (May be taken thrice provided that the topics are not the same; topic(s) to be specified for record purposes).

**399** **Independent Doctoral Research in Biology.** Comprehensive literature survey, conceptualization and conduct of actual research and preparation of scientific manuscript on an advanced biological research problem. Prereq: Completion of 18 u of graduate courses. (6h lab). 2 u (may be taken thrice provided that the research topics are not the same,; topic(s) to be specified for record purposes).

**400** **PhD Dissertation.** Prereq: Passing of candidacy examination and completion of course requirements. 12 u.

**GRADUATE**

**Microbiology (Microbio)**

**211** **Microbial Systematics.** Microbial Diversity, phylogeny, and modern approaches to microbial classification and identification. Prereq: BIO 120/equiv. 7h. (1h lec, 6h lab). 3 u.

**212** **Ultrastructure of Microorganisms.** Basic electron microscopy with emphasis on cytochemistry and various labeling

techniques as applied to microorganisms. Prereq: BIO 120/ equiv. 7 h. (1 lec, 6 lab) 3 u.

**221** **Advanced Microbial Physiology.** Advanced concepts of microbial nutrition and metabolism; microbial physiology mechanisms applicable to food, industrial, medical and environmental microbiology. Prereq: BIO 123/equiv. 3 u.

**241** **Advanced Microbial Genetics.** Advanced genetic analysis of microbial systems; molecular mechanisms of gene regulation and gene transfer in microorganisms. Prereq: BIO 141/equiv. 5 h (2h lec, 3h lab). 3 u.

**251** **Microbial Pathogenesis.** Molecular mechanism of virulence and host-pathogen interactions. Prereq: BIO 125/Bio 151/ equiv. (3h lec). 3 u.

**261** **Advanced Microbial Ecology.** Advanced concepts of microbial ecology; microbial diversity and its relationship to environmental quality and sustainability. Prereq: BIO 163/ equiv. 5 h. (2 lec, 3 lab) 3 u.

**262** **Soil Microbiology.** Systematics and ecology of soil microorganisms; techniques of studying growth and control of soil microflora. Prereq: BIO 163/equiv. 5 h. (2 lec, 3 lab) 3 u.

**271** **Protozoology.** Prereq: Bio 116, Bio 117./equiv.

**281** **Industrial Microbiology.** Economically important microorganisms and their application in industry. Prereq: BIO 120/equiv. 7 h. (1 lec, 6 lab) 3 u.

**296** **Seminar.** Prereq: Completion of 12 u. of graduate courses. 1 u.; may be taken twice.

**299** **Research in Microbiology.** Prereq: Completion of 12 u. of graduate courses. 6 h. (lab) 2 u.

**300** **M.S. Thesis.** Prereq: completion of all course work. 6 u.

## INSTITUTE OF CHEMISTRY (ICHEM)

### GENERAL EDUCATION COURSE

**Chemistry (Chem)**

**1**[a] **Chemistry: Science that Matters.** Basic Chemistry concepts relevant to everyday life. 3 u.

[a]*Math, Science and Technology domain*
[b]*Sequencial courses*

### UNDERGRADUATE

**Chemistry (Chem)**

**16**[b] **General Chemistry I.** Fundamentals of chemistry. Prereq/ Coreq: Math 11/equiv. 9 h. (3 class, 6 lab) 5 u.

**17**[b] **General Chemistry II.** Continuation of Chemistry 16. Prereq: Chem 16, Math 14/equiv. 9 h. (3 class, 6 lab) 5 u.

**26** **Introduction to Quantitative Chemical Analysis.** Basic principles of analytical chemistry with emphasis on stoichiometry and equilibrium concepts and calculations. Prereq: Chem 16, Math 17/ equiv.; to be taken simultaneously with Chem 26.1. 3 u.

**26.1** **Introduction to Quantitative Chemical Analysis Laboratory.** Prereq: To be taken simultaneously with Chem 26. 6 h. (lab) 2 u.

**28** **Fundamentals of Analytical Chemistry.** Principles and techniques of absolute methods of analysis and selected comparative methods. Prereq: Chem 17. Coreq: Chem 28.1 (for non-BS Chem majors) or Chem 101.1 (for BS Chem majors). 3 u.

**28.1** **Fundamentals of Analytical Chemistry Laboratory.** Prereq: To be taken simultaneously with Chem 28. 6 h. (lab) 2 u.

**31** **Elementary Organic Chemistry.** Introduction to modern theories in organic chemistry. Correlation of structue with properties of organic compounds. Prereq: Chem 16/equiv; to be taken simultaneously with Chem 31.1. 3 u.

**31.1** **Elementary Organic Chemistry Laboratory.** Prereq: To be taken simultaneously with Chem 31. 6 h. (lab) 2 u.

**33**[b] **Fundamentals of Organic Chemistry . I**ntroduction to modern concepts in organic chemistry. Discussion of electronic and structural effects on reaction mechanisms. Chem 17. 3 u.

**33.1** **Organic Chemistry I Laboratory.** Prereq: To be taken simultaneously with Chem 33. 6 h. (lab) 2 u.

**34**[b] **Organic Reactions and Spectroscopy.** An integrated application of modern concepts in organic chemistry to physical properties and chemical reactivities of organic compounds. Prereq: Chem 33. 3 u.

**34.1** **Organic Chemistry II Laboratory.** Prereq: To be taken simultaneously with Chem 34. 6 h. (lab). 2 u.

**40** **Elementary Biochemistry.** An elementary treatment of structure-function relationship of biomolecules and biochemical mechanisms. Prereq: Chem 26, 26.1, 31, 31.1/Chem 17, Chem 31, 31.1/equivs.; to be taken simultaneously with Chem 40.1. 3 u.

**40.1** **Elementary Biochemistry Laboratory.** Prereq: To be taken simultaneously with Chem 40. 6 h. (lab) 2 u.

**101.1 Laboratory Techniques for Organic and Analytical Chemistry.** Intergrated experiments in basic organic chemistry reactions, physical methods, sampling, gravimetric analysis and titrimetric analysis; introduction to chromatography, potentiometry and spectrophometry; safety and chemical waste management. Prereq: to be taken simultaneously with Chem 28 and Chem 33. 9 h (lab). 3 u.

**101.2 Organic Reactions and Instrumental Methods of Analysis.** Integrated experiments involving methods of synthesis, as well as intrumental techniques in analytical and organic chemistry such as spectroscopy, chromatography and electrochemistry; safety and chemical waste management. Prereq: Chem 101.1 to be taken simultaneously with Chem 34 and Chem 123. 9 h. (lab)3 u.

**102.1 Integrated Laboratory for Biochemistry, Inorganic Chemistry and Physical Chemistry.** Intergrated experiments involving laboratory techniques in biochemistry, inorganic and physical chemistry (e.g., kinetic, separation and spectroscopic methods); synthesis; safety and chemical waste management. Prereq: Chem 145, Chem 145.1 and Chem 153. Coreq: Chem 146 and Chem 154. 9 h. (lab) 3 u

**102.2 Advanced Integrated Laboratory for Biochemistry, Inorganic Chemistry and Physical Chemistry.** Intergrated experiments involving advanced laboratory techniques in biochemistry, inorganic and physical chemistry (e.g., kinetic, separation and spectroscopic methods); synthesis; safety and chemical waste management. Prereq: Chem 102.1 and Chem 112. 9 h. (lab) 3 u.

**105 Mathematical Methods for Chemistry.** Applications of mathematical methods to specific chemistry problems. Prereq: Math 54. 3h. (lec). 3 u.

**112 Principles of Inorganic Chemistry and their Applications to Representative Elements.** Structure, bonding, and chemical reactivities of representative elements and their compounds. Prereq: Chem 28. 3 u.

**112.1 Inorganic Chemistry Laboratory.** Preparation and characterization of inorganic compounds. Prereq: Chem 28, 28.1, 34, 34.1; to be taken simultaneously with Chem 112. 6 h. (lab) 2 u.

**113 Transition and Rare Earth Elements and their Compounds.** Chemical structures, properties and reactivities of *d*- and *f*-block elements and their compounds. Prereq: Chem 112. 3h. (lec). 3 u.

**123 Advanced Analytical Chemistry.** Principles and applications of instrumental methods with emphasis on separations, spectroscopic and electrochemical methods; introduction to quality assurance in the analytical laboratory. Prereq: Chem 28, 33, 101.1; to be taken simultaneously with Chem 34 and 101.2. 3 u.

**123.1 Advanced Analytical Chemistry Laboratory.** Prereq: to be taken simultaneously with Chem 123. 6 h. (lab) 2 u.

**125 Basic Electronics for Chemical Instrumentation.** Basic principles of instrumentation in spectrophotometric, electrometric and separation methods; fundamentals of electronics. Prereq: Chem 28, 34, Physics 72. 6 h. (3 lec, 3 lab) 4 u.

**145 Principles of Biochemistry.** Concepts in structure and function of the major biomolecules; bioenergetics, kinetics and mechanisms of enzyme catalysis, modulation and inhibition. Prereq: Chem 28, 34, 101.1, 101.2. 3 u.

**145.1 Laboratory Techniques in Biochemistry.** Fundamental techniques in biochemistry for extracting, handling and characterizing the major classes of biomolecules. These techniques are used for molecules of high molecular weights, which are relatively unstable and often denaturable with techniques ordinarily applied for small molecules. Coreq: Chem 145. 3 h. (lab). 3 u.

**146 Biochemistry of Metabolism and Informational Pathways.** Primary catabolic and anabolic pathways; gene replication, expression and regulation; hormones and signaling pathways. Prereq: Chem 145; to be taken simultaneously with with Chem 102.1. Coreq: Chem 146.1. 3 u.

**146.1 Biochemistry Laboratory.** Coreq: Chem 146. 6 h. (lab) 2 u.

**150 Introduction to Physical Chemistry.** General principles of physical chemistry with emphasis on their application to biological systems. Prereq: Chem 26, 26.1, 31, 31.1/equiv. 3 u.

**150.1 Introduction to Physical Chemistry Laboratory.** Prereq/ Coreq: Chem 150. 3 h. (lab) 1 u.

**153[a] Physical Chemistry: Foundations of Chemical Thermodynamics.** Fundamental relations and equations in state. Prereq: Chem 105 or COI. 3 u.

**153.1 Physical Chemistry I Laboratory.** Coreq: Chem 153. 6 h. (lab) 2 u.

**154[a] Physical Chemistry of Real Systems.** Electrochemistry, chemical kinetics and reaction mechanisms, surface phenomena, colloids, and transport properties. Prereq: Chem 153 or ChE 122, and Physics 72. 3 u.

**154.1 Physical Chemistry II Laboratory.** Coreq: Chem 154. 6 h. (lab) 2 u.

**156 Introduction to Quantum Chemistry.** Principles of quantum mechanics applied to atomic and molecular structure; approximate methods for complex atoms and molecules. Prereq: Chem 153 and Physics 72. 3 u.

**196 Undergraduate Seminar.** Prereq: SS. 1 u., may be taken twice.

**197 Special Topics in Applied Chemistry.** Prereq: SS. 3 u.

[a]*Sequential course*

**200** **Undergraduate Thesis.** 4 u. ( 1 yr., 2 u./sem.).

**GRADUATE**

**Chemistry (Chem)**

**201** **Chemistry for Teachers of College Chemistry.** 6 h. (3 lec, 3 lab) 4 u.

**203** **Environmental Chemistry.** Chemistry applied to the study of the environment, its pollution, and control. 3 u.

**203.1** **Environmental Chemistry Laboratory.** The chemical analysis of soil, water and air samples. Coreq: Chem 203. 6 h. (lab) 2 u.

**211** **Systematic Inorganic Chemistry.** Study of the chemistry of the metallic and nonmetallic elements. Prereq: Chem 112, 156/COI. 3 u.

**212** **Reaction Mechanisms of Transition Metal Complexes.** Mechanisms of reactions of first- and second-series transition metal ions in relation to their structures. Prereq: Chem 211/ COI. 3 u.

**213** **Physical Methods of Inorganic Chemistry.** Applications of spectroscopy and other modern physical techniques to the study of inorganic compounds. Prereq: Chem 211/COI. 3 u.

**214** **Inorganic Synthesis.** Methods of synthesis of inorganic and organometallic compounds. Prereq: Chem 211/COI. 8 h. (2 lec, 6 lab) 4 u.

**215** **Coordination Chemistry.** Bonding and structure of coordination compounds; quantitative interpretation of spectral, magnetic and crystallographic data. Prereq: Chem 211/COI. 9 h. (3 lec, 6 lab) 5 u.

**216** **Bioinorganic Chemistry.** Structure, bonding, and mechanistic aspects of metal ion involvement in biological processes. Prereq: Chem 211/COI. 3 u.

**217** **Nuclear Chemistry.** Theories of radioactive decay; nuclear reactions. Prereq: Chem 154/COI. 3 u.

**218** **Organometallic Chemistry of the Transition Metals.** A study of metal complexes using carbon as the ligating atom. Prereq: Chem 211/COI. 3 u.

**219** **Solid State Chemistry.** Structure and bonding in solid state materials. Prereq: Chem 211/ COI. 3 u.

**220** **Instrumental Methods of Analysis.** Fundamentals of chemical instrumentation; theory and application of some common instrumental methods. Prereq: Chem 123/COI. 3 u.

**220.1** **Laboratory in Instrumental Methods of Analysis.** Prereq: Chem 123.1/COI. Coreq: Chem 220. 6 h. (lab) 2 u.

**221** **Electroanalytical Chemistry.** Theory of modern electrochemical methods, such as cyclic voltammetry, stripping analysis, AC and differential pulse polarography and ring-disk electrodes. Prereq: Chem 220/COI. 3 u.

**222** **Optical Methods of Analysis.** Fundamentals of optical instrumentation; principles and applications of spectroscopy and spectrophotometry. Prereq: Chem 220/COI. 3 u.

**223** **Theoretical Analytical Chemistry.** Theory of analytical separations based on chemical and phase equilibria. Prereq: Chem 123/COI. 3 u.

**224** **Aquatic Chemistry.** The composition, properties and processes in natural aquatic systems. Prereq: Chem 220/223/COI. 3 u.

**225** **Modular Chemical Instrumentation.** Fundamentals of analog and digital electronics; modular approach to chemical instrumentation. Prereq: Chem 220/COI. 5 h. (2 lec, 3 lab) 3 u.

**226** **Analytical Separation Methods.** Advanced treatment of separations theory and its application to some common analytical separation methods. Prereq: Chem 223/COI. 3 u.

**227** **Radioisotope Techniques.** Methods of chemical separation, detection and measurement of radioactive substances; application to chemical problems. Prereq: Chem 217/COI. 8 h. (2 lec, 6 lab) 4 u.

**230** **Physical Organic Chemistry I.** Application of physical chemistry in the study of structure, reactivity, and reaction mechanisms of organic compounds. Prereq: Chem 154, 34/COI. 3 u.

**231** **Polymer Chemistry.** Synthesis, physical and chemical properties, structure and function of synthetic and natural polymers. Prereq: Chem 230/COI. 3 u.

**231.1** **Polymer Chemistry Laboratory.** Methods and techniques in polymer synthesis; testing and characterization of polymers. Prereq: Chem 231/COI. 6 h. (lab) 2 u.

**234** **Physical Organic Chemistry II.** Principles of stereochemistry and their application to the study of configuration, conformation and reaction mechanisms of organic compounds. Prereq: Chem 230/ COI. 3 u.

**235** **Theoretical Organic Chemistry.** Application of quantum chemistry in the study of structure, reactivity and reaction mechanisms of organic compounds. Prereq: Chem 156, 230/COI. 3 u.

**236** **Organic Synthesis.** Techniques of organic synthesis. Prereq: Chem 230/COI. 3 u.

**236.1** **Organic Synthesis Laboratory.** Experimental techniques in organic synthesis. Prereq: Chem 236/ COI. 6 h. (lab) 2 u.

**237** **Spectroscopic Methods in Organic Chemistry.** Application of nmr, esr, ir, uv-vis, and mass spectrometry in organic chemistry. Prereq: Chem 230/COI. 3 u.

**238** **Heterocyclic Chemistry.** Synthesis, properties and chemical reactivity of N-, O-, S-containing heterocyclic compounds. Prereq: Chem 230/COI. 3 u.

**239** **Natural Products Chemistry.** Chemistry and biogenesis of major classes of secondary metabolites. Prereq: Chem 230/COI. 3 u.

**240** **Advanced Biochemistry.** Structure and conformation of biomolecules; electronic indices and reactivity of biomolecules; fundamental techniques used in the study of biomolecules. Prereq: Chem 146/COI. 3 u.

**241** **Lipids and Related Systems.** Structure-function correlations, cellular utilization and regulation mechanism. Prereq: Chem 240/COI. 3 u.

**242** **Carbohydrates and Related Systems.** Structure-function correlations, cellular utilization and regulation mechanisms. Prereq: Chem 240/COI. 3 u.

**243** **Nucleic Acids.** Structure-function correlations and mechanisms of cellular utilization and regulation of nucleic acids. Prereq: Chem 240/COI. 3 u.

**244** **Proteins.** Structure-function correlations and mechanisms of cellular utilization and regulation of proteins. Prereq: Chem 240/COI. 3 u.

**245** **Enzymes.** The chemical nature of enzymes and coenzymes, their general methods of preparation and investigation, the kinetics and mechanism of their action, etc. Prereq: Chem 244/COI. 3 u.

**247** **Molecular Biochemistry.** Behavior of biologically active substances and mechanisms of enzymic reactions in terms of electronic theory. Prereq: Chem 240/COI. 3 u.

**248** **Metabolic and Information Pathways.** Integration and regulation of catabolic and biosynthetic processes; biochemistry of informational molecules. Prereq: Chem 240/COI. 3 u.

**250** **Chemical Thermodynamics I.** Thermodynamics theory; applications to chemical and other related systems; introduction to irreversible thermodynamics. Prereq: Chem 153/COI. 3 u.

**251** **Chemical Thermodynamics II.** Ensembles and thermodynamics; non-interacting systems; interacting systems; quantum statistics. Prereq: Chem 156, 250/COI. 3 u.

**252** **Graduate Physical Chemistry Laboratory.** Prereq: COI. 2 u.

**255** **Quantum Chemistry.** Approximation methods; non-interacting particles; the chemical applications of group theory. Prereq: Chem 156/COI. 3 u.

**256** **Advanced Quantum Chemistry.** Representation theory; quantum transitions under the influence of external perturbation; quantum theory of scattering; approximation methods. Prereq: Chem 255/COI. 3 u.

**257** **Chemical Kinetics.** Reaction rates and mechanisms. Prereq: Chem 154/COI. 3 u.

**288** **Chemistry Teaching Practicum.** Prereq: COD; passed compre exams. 2 u.

**289** **Special Problem in Chemical Education.** Prereq: Consent of the Graduate Committee; passed compre exams. 2 u.

**291** **Seminar in Inorganic Chemistry.** Prereq: Completion of 9 u. in the MS program. 1 u.

**292** **Seminar in Analytical Chemistry.** Prereq: Completion of 9 u. in the MS program. 1 u.

**293** **Seminar in Organic Chemistry.** Prereq: Completion of 9 u. in the MS program. 1 u.

**294** **Seminar in Biochemistry.** Prereq: Completion of 9 u. in the MS program. 1 u.

**295** **Seminar in Physical Chemistry.** Prereq: Completion of 9 u. in the MS program. 1 u.

**300** **MS Thesis.** Prereq: completion of all course requirements. 6 u.

**319**[a] **Special Topics in Inorganic Chemistry.** Trends and developments in inorganic chemistry. Prereq: COI. 3 u.

**319.1**[a] **Special Topics in Experimental Inorganic Chemistry.** Prereq: COI. 1 u.

**329**[a] **Special Topics in Analytical Chemistry.** Trends and developments in analytical chemistry. Prereq: COI. 3 u.

**329.1**[a] **Special Topics in Experimental Analytical Chemistry.** Prereq: COI. 1 u.

**339**[a] **Special Topics in Organic Chemistry.** Trends and developments in organic chemistry. Prereq: COI. 3 u.

**339.1**[a] **Special Topics in Experimental Organic Chemistry.** Prereq: COI. 1 u.

**349**[a] **Special Topics in Biochemistry.** Trends and developments in biochemistry. Prereq: COI. 3 u.

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[a] *May be taken more than once for credit if topical coverage is different.*

**349.1**[a] **Special Topics in Experimental Biochemistry.** Prereq: COI. 1 u.

**359**[a] **Special Topics in Physical Chemistry.** Trends and developments in physical chemistry. 3 u.

**359.1**[a] **Special Topics in Experimental Physical Chemistry.** Prereq: COI. 1 u.

**391** **Research Seminar in Inorganic Chemistry.** Prereq: Completion of 12 u. in the PhD program. 1 u.

**392** **Research Seminar in Analytical Chemistry.** Prereq: Completion of 12 u. in the PhD program. 1 u.

**393** **Research Seminar in Organic Chemistry.** Prereq: Completion of 12 u. in the PhD program. 1 u.

**394** **Research Seminar in Biochemistry.** Prereq: Completion of 12 u. in the PhD program. 1 u.

**395** **Research Seminar in Physical Chemistry.** Prereq: Completion of 12 u. in the PhD program. 1 u.

**400** **Ph.D. Dissertation.** Prereq: Completion of all course requirements and passing of candidacy examination. 12 u.

## NATIONAL INSTITUTE OF GEOLOGICAL SCIENCES

### GENERAL EDUCATION COURSE

#### Geology (Geol)

**1**[b] The study of how the earth works, its place in the universe; and relationship between people and the physical environment. 3 u.

### UNDERGRADUATE

#### Geology (Geol)

**11** **Principles of Geology.** Earth materials; nature and consequences of geologic processes. 3 u.

**11.1** **Laboratory in Principles of Geology.** Mineral and rock specimens; interpretation of geologic maps and sections. A field trip. Coreq: Geol 11. 3 h. (lab) 1 u.

**40** **Elementary Mineralogy.** Introduction to crystallography and to the physics and chemistry of minerals.Prereq: ES 1, Math 17, Chem 16, Geol 11.1. 8 h. (2 lec, 6 lab) 4 u.

**50** **Elementary Petrology.** Megascopic examination and classification of rocks; concepts of rock origin. Prereq: Geol 40. 8 h. (2 lec, 6 lab) 4 u.

**60** **Historical Geology.** Earth history and ancient life as recorded in rocks. Prereq: Geol 50. 6 h. (3 lec, 3 lab) 4 u.

**70** **Field Methods in Geology.** Introduction to techniques in geologic mapping, map reading, brunton tape traverse, recognition and recording of geologic features. Writing of geologic reports. Field trips. Prereq: Geol 11.1, GE 11. 3 h. (lab) 1 u.

**105** **Introduction to Geochemistry.** Chemistry in the study of geological problems. Prereq: Geol 50, Chem 26, 26.1/equiv. 3 u.

**112** **Structural Geology.** Mechanics of rock deformation; nature, origin, types, and field examples of primary and secondary rock structures. Prereq: Physics 71, 71.1, Geol 50, 70. 6 h. (3 lec, 3 lab) 4 u.

**120** **Principles of Stratigraphy.** Concepts and procedures in the classification and correlation of rock units. Field trips. Prereq: Geol 60, 70. 6 h. (3 lec, 3 lab) 4 u.

**122** **Principles of Geomorphology.** Land forms, their origin and modification. Introduction to aerial photo interpretation. Prereq: Geol 11.1. 6 h. (3 lec, 3 lab) 4 u.

**130** **Elementary Paleontology.** Biology of animal and plant fossils based on living representatives. Stratigraphic distribution. Prereq: Geol 60. 6 h. (3 lec, 3 lab) 4 u.

**131** **Micropaleontology.** Introduction to animal and plant microfossils. Emphasis on Foraminifera. Prereq: Geol 130. 6 h. (3 lec, 3 lab) 4 u.

**140** **Optical Mineralogy.** Principles of crystal optics, identification of minerals in grain and thin-section. Prereq: Geol 40. 8 h. (2 lec, 6 lab) 4 u.

**150** **Petrography and Petrology.** Microscopic examination and classification of igneous, sedimentary, and metamorphic rocks. Genesis. Prereq: Geol 50, 140. 9 h. (3 lec, 6 lab) 5 u.

**170** **Field Geology.** An introduction to independent geologic mapping, field research, and preparation of a formal geologic report. Prereq: Geol 112, 120. 6 wks. (4 field, 2 lab) 6 u.

**171** **Mineral Data Analysis.** Statistical techniques in the analysis and interpretation of mineral and geological data. Prereq: Math 101/COI. 3 u.

**172** **Introduction to Geostatistics.** Principles, concepts and models in geostatistics. Examination of the bases, implications, uses and limitations of prevailing geostatistical models. Prereq: Geol 171, 194/ COI. 3 u.

**173** **Introduction to Earth Resource Economics.** Principles of economics necessary for understanding the behavior and characteristics of earth resource based industries. Prereq: Econ 11. 3 u.

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[a] *May be taken more than once for credit if topical coverage is different*

[b] *Math, Science and Techology domain.*

**174** **Introduction to Earth Resources Project Evaluation.** Principles of earth resources project evaluation, including environmental impact assessment; application to exploration projects; case studies. Prereq: Geol 173. 5 h. (2 lec, 3 lab) 3 u.

**175** **Computer Methods in Geology.** Application of computer methods in various fields of geology. Prereq: SS. 5 h. (2 lec, 3 lab) 3 u.

**177** **Geology of the Philippines and Southeast Asia.** Geologic evolution of the Philippines and Southeast Asia. Prereq: SS. 3 u.

**181** **Elementary Geophysics.** Fundamentals of physics of the earth and their application. Prereq: Math 55, Physics 73, 73.1, Geol 190; Coreq: Geol 194. 6 h. (3 lec, 3 lab) 4 u.

**190** **Petroleum Geology.** The occurrence, origin, and accumulation of petroleum; exploration methods. Prereq: Geol 112, 120. 3 u.

**192** **Non-Metallic Ore Deposits.** Nature, occurrence, and origin of coal and certain industrial minerals and rocks. Prereq: Chem 26, 26.1/equiv, Geol 112, 120. 6 h. (3 lec, 3 lab) 4 u.

**194** **Metalliferous Ore Deposits.** Nature, occurrence, and origin of metalliferous deposits. Prereq: Chem 26, 26.1/equiv, Geol 112, 150/COI. 9 h. (3 lec, 6 lab) 5 u.

**196** **Undergraduate Seminar.** Discussion of important topics in geology from current literature. Prereq: SS. 2 u.

**GRADUATE**

**Geology (Geol)**

**203** **Geochemical Exploration.** Geochemical principles, techniques, interpretation, and procedures in geochemical exploration for mineral deposits. Prereq: Geol 105/COI. 2 h. (lec) 6 days field/sem. 3 u.

**205** **Geochemistry.** Distribution of chemical elements and isotopes in geologic environments; acquisition and interpretation of geochemical data. Prereq: Geol 105/COI. 5 h. (2 lec, 3 lab) 3 u.

**207** **Mineral Equilibria.** Phase equilibria in multicomponent systems. Prereq: Geol 105/COI. 2 u.

**208** **Geochemistry of Hydrocarbons.** Geochemistry of coal petroleum and natural gas in relation to their genesis. Prereq: GS. 3 u.

**212** **Advanced Structural Geology.** Tectonic elements and their patterns; theories of orogenesis. Prereq: Geol 112, 120, 150/COI. 3 u.

**213** **Photogeology and Remote Sensing.** Concepts of remote sensing and geological interpretation of remote sensing imagery. Prereq: Geol 112, 122. 4 h. (1 lec, 3 lab) 2 u.

**214** **Geotectonics.** Structure evolution of the crust, continents, island arcs and oceans using East and Southeast Asia among the models. Prereq: GS. 3 u.

**215** **Advanced Field Geology.** Mapping in complex geologic terranes. Prereq: Geol 170. 3 h. (lab) 2 wks. field/sem. 3 u.

**216** **Geology for Large Infrastructures.** Principles and practice of geology in relation to the construction of large infrastructure projects. Prereq: COI. 3 h. (2 lec, 1 lab/field) 3 u.

**217** **Hydrogeology.** Principles and practice of groundwater exploration and development. Prereq: COI. 3 h. (2 lec, 1 lab) 3 u.

**218** **Urban Geology.** Concepts and techniques of geology as applied to the planning, development and construction of public and private structures in urban communities. Prereq: COI. 3 u.

**230** **Marine Geology.** Geologic structure of ocean basins and continental margins; geologic processes in marine regimes. 5 h. (2 lec, 3 lab) 3 u.

**232** **Systematic Invertebrate Paleontology.** Selected phyla of fossils. Prereq: Geol 60/COI. 8 h. (2 class, 6 lab) 4 u.

**237** **Advanced Micropaleontology.** Study of large and small foraminifera with emphasis on Philippine materials. Prereq: Geol 131. 8 h. (2 lec, 6 lab) 4 u.

**241** **X-ray Crystallography and Spectrography.** X-ray methods for the characterization of crystal structure and determination of chemical composition. Prereq: COI. 8 h. (2 lec, 6 lab) 4 u.

**243** **Crystal Chemistry and Crystal Physics.** Physical and chemical properties, structure types and stability of common rock-forming minerals. Prereq: COI. 2 u.

**250** **Igneous Petrology.** Igneous rock associations and their origins, with emphasis on Philippine rocks: microscopic study of igneous rocks including mineral examination with the use of universal stage. Prereq: Geol 150/COI. 5 h. (2 lec, 3 lab) 6 days field/sem. 4 u.

**251** **Metamorphic Petrology.** Properties and origin of metamorphic rocks; techniques applied to the study of metamorphic rocks. Prereq: Geol 150/COI. 5 h. (2 lec, 3 lab) 6 days field/sem. 4 u.

**252** **Sedimentology.** Processes and materials in sedimentary environments; application to selected Philippine examples. Prereq: Geol 120/COI. 2 h. (lec) 6 days field/sem. 3 u.

**253** **Sedimentary Petrology.** Genesis and classification of common sediments and sedimentary rocks, analysis and interpretation of fabric and composition of sedimentary rocks. Prereq: Geol 150/COI. 8 h. (2 lec, 6 lab) 4 u.

**254** **Volcanism.** Causes of volcanic activity; geochemistry and experimental petrology relating to the generation of lavas. Prereq: Geol 105/COI. 3 u.

**255** **Geothermal Resources.** Geology, geochemistry and geophysics of geothermal resources; techniques of exploration, evaluation and development. Prereq: Geol 105/COI, 181. 5 h. (2 lec, 3 lab) 3 u.

**260** **Stratigraphic Analysis.** Application of stratigraphic principles to local and regional problems. Techniques in stratigraphic analysis. Prereq: Geol 120/COI. 5 h. (2 lec, 3 lab) 6 days field/sem. 4 u.

**261** **Paleogeology.** Regional studies of geologic history by use of isopach, paleogeologic, and facies maps. Prereq: COI. 7 h. (1 class, 6 lab) 3 u.

**270** **Ore Microscopy.** Advanced microscopic techniques in ore mineral identification, interpretation of their textures and relationship with respect to the origin of a deposit; application to mineral processing. Prereq: Geol 194/COI. 8 h. (2 lec, 6 lab) 4 u.

**271** **Mining Geology.** Application of geology to the search for, and the exploration, development and exploitation of, mineral deposits. Prereq: GE 14, COI. 5 h. (2 class, 3 lab) 3 u.

**272** **Advanced Petroleum Geology.** Problems in the occurrence and accumulation of petroleum. Prereq: Geol 190. 2 u.

**273** **Advanced Mineral Deposits.** Ore deposit types and origin of mineral deposits with emphasis on Philippine examples. Prereq: Geol 194. 2 h. (class) 6 days field/sem. 3 u.

**274** **Environmental Geology.** The application of geologic principles and concepts in environmental and resource assessment and management. Prereq: Geol 174/COI. 6 h. (3 lec, 3 lab) 4 u.

**275** **Mineral Resource Economics.** Geologic and economic bases of mineral resources; basic issues in resource extraction; analytical models. Prereq: Geol 173/COI. 3 u.

**276.2** **Metallic Mineral Resources.** Analysis of major metallic mineral resources; behavior and implication to Philippine and world economies. Prereq: Geol 275/COI. 5 h. (2 lec, 3 lab/field) 3 u.

**276.3** **Nonmetallic Mineral Resources.** Analysis of major nonmetallic mineral resources; behavior and implication to Philippine and world economies. Prereq: Geol 275/COI. 5 h. (2 lec, 3 lab/field) 3 u.

**276.4** **Energy Resources.** Analysis of the major energy resources; behavior and implications to Philippine and world economies. Prereq: Geol 275/COI. 3 u.

**277.1** **Quantitative Methods in Mineral Economics I.** Linear stochastic modeling; application to mineral problems. Prereq: Geol 171, 275/COI. 5 h. (2 lec, 3 lab) 3 u.

**277.2** **Quantitative Methods in Mineral Economics II.** Principles of linear programming, input-output and related models; applications to mineral industry problems. Prereq: Geol 171, 275/COI. 5 h. (2 lec, 3 lab) 3 u.

**278** **Quantitative Methods Applied to Exploration.** Statistical and computer programming approach to mineral exploration. Problems of optimum search and efficient sampling schemes, ore reserve calculations and valuation. Prereq: Geol 172, 181, 194/COI. 3 u.

**279** **Energy and Mineral Policies.** Concepts, principles and constraints relevant to the formulation, implementation, monitoring and evaluation of energy and mineral development policies. Prereq: COI. 3 u.

**281** **Geophysical Exploration I.** Theory and application of gravity and magnetic methods of exploration. Prereq: Geol 181 (may be taken concurrently), Math 121.1. 5 h. (2 class, 3 lab) 3 u.

**282** **Geophysical Exploration II.** Theory and application of refraction and reflection seismic methods of exploration. Prereq: Geol 181 (may be taken concurrently), Math 121.1. 5 h. (2 class, 3 lab) 3 u.

**283** **Geophysical Exploration III.** Theory and application of electrical and electromagnetic methods of exploration. Prereq: Geol 181, Math 121.1. 5 h. (2 lec, 3 lab) 3 u.

**284** **Solid Earth Geophysics.** Seismology; the structure and the composition of the earth's interior. Prereq: Geol 194. 3 u.

**285** **Geophysical Prospecting.** Use of geophysical instruments in mineral exploration. Prereq: Geol 181. 2 h. (lec) 6 days field/sem. 3 u.

**289** **Economics and Management of Mineral Exploration and Development.** Models, approaches and practices commonly used in the energy/mineral industries. Prereq: COI. 3 u.

**290** **Fundamental Problems in Geology.** Selected fundamental problems in geology, their relationships to each other; integration of the different branches of geology and of other sciences towards solution of these problems. Prereq: COI. 3 u.

**296** **Seminar: (Subject Title).** Prereq: COI, may be taken twice, topic to be indicated for record purposes. 2 u.

**297** **Special Topics: (Subject Title).** Prereq: COI, may be taken twice, topic to be indicated for record purposes. 3 u.

**298** **Seminar in Mineral Economics.** 2 u.

**300** **Master's Thesis.** 6 u.

**331** **Environmental Geology.** Conservation and management of earth resources and application of geologic data for urban, rural and regional development projects. 3 u.

**399** **Research: (Subject Title).** Prereq: COI, may be taken twice, topic to be indicated for record purposes. 3 u.

**400** **PhD Dissertation.** 12 u.

**MARINE SCIENCE INSTITUTE**

**GENERAL EDUCATION COURSE**

**Marine Science (MS)**

**1**[a] **Oceans and Us.** An appreciation course on the functional balance between the health of the oceans and the survival and improvement of our way of life. 3 u.

**UNDERGRADUATE**

**Marine Science (MS)**

**101** **Oceans.** Concepts necessary for a broad understanding of the physics, chemistry, geology, and biology of the oceans. 3 u.

**102** **The Marine Sciences.** An introduction to the subdisciplines of marine science (e.g. marine biology, marine chemistry, marine geology and physical oceanography), with empahis on tropical marine ecology. Prereq: COI. 3 u.

**Marine Science (MS)**

**201** **Ocean Physics and Chemistry.** Introduction to physical and chemical properties and processes in marine waters. Prereq: Introductory Calculus, Elementary Organic Chemistry and basic Physical Chemistry. 3 u.

**210** **Physical Oceanography.** Physical properties of seawater, general distribution of salinity, temperature and density, waves and currents, ocean atmosphere interactions. Prereq: Math 100/COI. 3 u.

**213** **Dynamics of Oceans.** Dynamical principles which govern the behavior of the oceans in response to the effects of gravity, rotation, stratification and other external forces. Prereq: MS 210/COI. 3 u.

**214** **Waves and Tides.** Surface, long, standing, and internal waves; seiches, tsunamis, storm surges, swells, tide-producing forces and tides. 3 u.

**216** **Numerical Ocean Modeling.** Wind-driven barotropic models; simple thermohaline models; baroclinic models; mixed layer models; problems in ocean modeling. Prereq: MS 211/COI. 3 u.

**217** **Coastal and Estuarine Oceanography.** Ocean dynamics modified by thermohaline effects, presence of coast and shallow bathymetry. Prereq: MS 213/COI. 3 u.

**220** **Chemical Oceanography.** Chemical features of and processes in marine waters and sediments, and their interrelationships with the physical and biological systems. Prereq: Analytical Chemistry/COI. 3 u.

**221** **Marine Geochemistry.** The study of oceans as a geochemical systems with emphasis on global biogeochemical cycles. Prereq: MS 220/COI. 3 u.

**222** **Chemistry of Marine Coastal Environments.** Applications of principles of chemical oceanography to the understanding of various coastal systems including coral reefs, mangroves, seagrass beds, and estuaries. Prereq: MS 220/COI. 3 u.

**226** **Marine Pollution Chemisty.** Sources, sinks and fate of various types of pollutants in the marine environment. Prereq: General Inorganic Chem, General Organic Chem, and Analytical Chem/ equivs/ COI. 3 u.

**226.1** **Marine Pollution Chemistry Laboratory.** Field and laboratory studies to apply concepts and techniques in marine pollution chemistry. Coreq: MS 226. 6 h. (lab) 2 u.

**230** **Geological Oceanography.** An introduction to the origin, morphology, structure and processes of the sea floor and ocean margins. (For non-geology majors) Prereq: Geol 11/ COI. 3 u.

**240** **Biological Oceanography.** The relationship of biological systems to the marine physico-chemical environment. Prereq: MS 201/210. 3 u.

**242** **Marine Microbiology.** The diversity and role of marine microorganisms in energy flow and biogeochemical cycling. Prereq: COI. 3 u.

**246** **Marine Phytoplankton.** Marine phytoplankton and their role in primary productivity. Prereq: BIO 111/ COI. 3 u.

**248** **Marine Zooplankton.** Marine zooplankton and their role in biological productivity. Prereq: BIO 116, 116.1/COI. 3 u.

**250** **Marine Ecology.** Fundamental ecological principles as applied to the marine environment. Prereq: Undergraduate ecology/ COI. 3 u.

**251** **Population Biology of Marine Organisms.** Study of populations of marine organisms, factors that regulate their size, interspecific interactions, and their life history strategies. Prereq: BIO 160, MS 240/equiv. 3 u.

**252** **Marine Biogeography.** Understanding the spatio-temporal variability in the distribution patterns of marine biota and the dynamic processes which cause these patterns. Prereq: COI. 3 u.

[a] *Math, Science and Technology domain.*

**253** **Marine Chemical Ecology.** The role of biomolecules (hormones, secondary metabolites, and others) in the interaction of marine organisms and their potential ecological and economic applications. Prereq: COI. 3 u.

**254** **Seagrasses and Mangroves.** Distribution and production ecology of seagrasses and mangroves with emphasis on their role in the productivity and stability of coastal habitats. Prereq: BIO 115, 160/equiv. 3 u.

**255** **Coral Reef Ecosystems.** Structure, function and ecological significance of coral reefs and their major living components. Prereq: COI. 3 u.

**256** **Marine Algae.** Taxonomy, morphology and ecology of marine benthic algae. Prereq: COI. 3 u.

**258** **Marine Fishes.** Taxonomy, morphology and ecology of marine fishes. Prereq: BIO 102. 3 u.

**260** **Marine Biodiversity.** The variety, variability and natural relations of marine living organisms viewed at the structural (organismal to ecosystem) level. Prereq: Undergraduate Ecology course/COI. 3 u.

**261** **Physiology of Marine Algae.** Physiological features of marine algae–growth and differentiation, structure–function relationships, and adaptation strategies. Prereq: MS 260/equiv/COI. 3 u.

**270** **Biochemistry of Marine Organisms.** Structure–function relationships of biomolecules, bioenergetics, catalysis, and regulation of metabolic pathways; and comparative biochemistry of marine organisms. Prereq: Elementary Biochemistry/COI. 3 u.

**272** **Marine Biotechnology I.** Principles of genomics, proteomics, bioinformatics, and genetic manipulation with emphasis on their application in the study of marine organisms. Prereq: Undergraduate-level courses in biochemistry, molecular biology, and genetics and COI. 3 u.

**273** **Marine Biotechnology II.** Molecular, biotechnological, and related techniques in the study and utilization of marine organisms. Prereq: MS 272. 3 u.

**278** **Marine Natural Products.** Survey of natural products from marine organisms: chemistry, biosynthesis, isolation, purification and biological activity. Prereq: MS 270/COI. 3 u.

**280** **Management of Marine Resources.** Biological and economic concepts for developing and managing the living resources of the sea. Prereq: BIO 101, 160/COI. 3 u.

**283** **Marine Agronomy.** Ecology and culture of economically important seaweeds and the utilization of their products. Prereq: MS 260/equiv. 3 u.

**300** **M.S. Thesis.** Prereq: Completion of all course requirements. 6 u.

**354** **Marine Ecosystem Dynamics.** Principles and processes underlying the structure and function of marine ecosystems. Prereq: MS 250/equiv/COI. 3 u.

**356** **Phylogeny and Systematics of Marine Organisms.** The principles of phylogenetic systematics with special reference to marine taxa. Prereq: MS 256/258/COI. 3 u.

**360** **Physiology of Marine Organisms.** Physiological adaptations of biota to the marine environment with focus on marine animals. Prereq: Undergraduate Animal Physiology course/COI. 3 u.

**361** **Reproductive Biology of Marine Organisms.** Reproduction in major groups of marine organisms with special reference to cycles and periodicity, in relation to internal and external control mechanisms. Prereq: COI. 3 u.

**366** **Population Genetics of Marine Organisms.** The principles of population genetics with emphasis on the application of genetic markers for the assessment and management of wild and cultured organisms. Prereq: Undergraduate genetics/COI. 3 u.

**385** **Marine Toxinology.** The biological significance, mode of production, biochemistry, toxinology and mechanism of action of marine toxins. Prereq: COI. 3 u.

**395** **Advanced Studies in Marine Science.** Conduct of actual research, preparation of scientific manuscript on an advanced research problem in Marine Science, and submission of manuscript to an Institute for Scientific Information (ISI) journal for peer-review. 12 h (lab). May be taken twice provided that the research topics are not the same; topic(s) to be specified for record purposes. 4 u.

**396** **Seminar.** Readings and public presentation on current research, issues and topics. 1 u.; every PhD student shall complete one seminar course every other year after 12 u. of courses have been credited to his/her program of study; MS students shall complete only one seminar course.

**397** **Special Topics in Marine Science.** Discussions on current and emerging topics/issues in the marine sciences. Prereq: COI. 3 u.; may be repeated for additional credit as long as the topics are not the same.

**398** **Advanced Methods in Marine Science.** Advanced and specialized techniques for the study of marine science. Prereq: COI. 3 u.

**399** **Research.** Conceptualization, conduct of actual research and preparation of scientific manuscript on a research problem. Prereq: COI. 3 u. (may be repeated for a maximum of 9 u.).

**400** **PhD Dissertation.** Prereq: Passing the candidacy examination and completion of all course requirements. 12 u.

**Tropical Marine Ecosystems Management (TMEM)**

**201** **Tropical Marine Ecosystems.** Ecological foundations of tropical marine ecosystems. (32 h lec, 48 h lab). 3 u.

**202** **Dynamics of Tropical Marine Socio-Ecological Systems.** Interactions of social, political, cultural, economic, and ecological dimensions in tropical marine ecosystems. Prereq: TMEM 201. (32 h lec, 96 h lab). 4 u.

**203** **Marine Environmental Planning and Management.** Principles and tools for marine environmental planning and management. Co-req: TMEM 202. (32 h lec, 96 h lab). 4 u.

**210** **Intercultural Understanding in the Management of Tropical Marine Ecosystems.** Multicultural realities and diversity issues in tropical marine ecosystem management in Southeast Asia and the Coral Triangle. (16 h lec). 1 u.

**211** **Communication in Tropical Marine Ecosystem Management.** Communicating knowledge, issues, and policies to stakeholders involved in tropical marine ecosystem management. (16 h lec). 1 u.

**220** **Marine Protected Area Management and Governance.** Integration of socio-ecological systems and designs; legal frameworks, governance and administration principles, and sustainable financing schemes. Prereq: TMEM 203. (32 h lec, 48 h lab). 3 u.

**221** **Strategic Planning for Marine Protected Areas.** Application of strategic planning principles and tools to marine protected areas. Prereq: 220. (48 h lec, 96 h lab). 5 u.

**222** **Marine Protected Area Management Plan Implementation.** Management processes, systems and standards in the operation of single site marine protected areas. Prereq: TMEM 221. (48 h lec, 96 h lab). 5 u.

**223** **Marine Protected Area Networks and Large Marine Ecosystems.** Networking and alliance building within and among local, provincial, and national entities for the governance of marine protected area systems. Prereq: TMEM 222. (48 h lec, 96 h lab). 5 u.[a]

**296** **Seminar.** Presentation of relevant issues in tropical marine ecosystem management. Prereq: COI. (16 h lec). 1 u.

**297** **Special Problem.** Prereq: TMEM 223, TMEM 296. (144 h lab). 3 u.

[a]*Math, Science and Technology domain. Math 1 cannot be taken by BS Mathematics students. Math 2 cannot be taken by students of degree programs which require at least Math 11.*

**UNDERGRADUATE**

**CWTS**

**CWTS1-CSMSI** Developing awareness of rural communities for marine biodiversity.

**CWTS2-CSMSI** Developing awareness of rural communities for marine biodiversity.

**INSTITUTE OF MATHEMATICS (I-MATH)**

**GENERAL EDUCATION COURSES**

**Mathematics (Math)**

**1[a]** **General Mathematics.** The development of mathematical literacy and appreciation through a synoptic view of the different branches of mathematics with historical notes and applications. 3 u.

**2[a]** **Practical Mathematics.** Basic mathematics skills and applications in everyday life. 3 u.

**UNDERGRADUATE**

**Mathematics (Math)**

**11** **College Algebra.** Linear equations; algebraic and graphical solutions of the quadratic equations; exponents and radicals; complex numbers; binomial expansion; determinants; progressions; theory of equations. Prereq: 1 yr. of high school algebra. 3 u.

**14** **Plane Trigonometry.** Logarithms; graphs of the trigonometric function; the general triangle; solutions of trigonometric; inverse trigonometric; exponential and logarithmic equations; complex numbers. Prereq: 1 yr. each of high school algebra and plane geometry. 3 u.

**17** **Algebra and Trigonometry.** Sets and numbers; the algebra of numbers as a logical system; inequalities; absolute values and coordinate systems, functions and graphs; circular, linear, quadratic and polynomial functions; exponential and logarithmic functions; applications of the circular functions to angles. Prereq: 1 yr. of high school algebra. 5 u.

**53** **Elementary Analysis I.** Functions and their graphs; concepts of limit and continuity; theory of differentiation; derivatives of algebraic and trigonometric functions; theory of integrals; applications of the definite integral. Prereq: Math 17/equiv. 5 u.

**54** **Elementary Analysis II.** Integration methods; determinants; plane and solid analytics; hyperbolic functions; polar coordinates; vectors; parametric equations. Prereq: Math 53. 5 u.

**55** **Elementary Analysis III.** Partial differentiation; multiple integrals; infinite series, differential equations. Prereq: Math 54. 3 u.

**60** **Precalculus.** Algebraic operations, functions, analytic geometry, trigonometry, matrices. 5 u.

**63** **Calculus I.** Functions of a single variable; limits; continuity; the derivative and the Riemann integral; derivatives of algebraic, trigonometric and inverse trigonometric functions; applications; polar coordinates; conic sections. Prereq: Math 60/equiv. 5 u.

**64** **Calculus II.** The exponential, logarithmic and hyperbolic functions; techniques of integration; vectors and vector-valued functions; improper integrals; infinite series; power series; applications. Prereq: Math 63/equiv. 5 u.

**65** **Calculus III.** Calculus of several variables and Fourier series. Prereq: Math 64/equiv. 3 u.

**100** **Introduction to Calculus.** Limits; derivatives; integrals; applications. Prereq: Math 17/COI. 4 u.

**102** **Intermediate Calculus.** Integration techniques; multivariate calculus; sequences and series; introduction to matrices; applications to economics, business, life and social sciences. Prereq: Math 100/equiv or Math 53/equiv. 3 u.

**109** **Fundamental Concepts of Mathematics.** Algebra of sets and logic; methods of proof; functions and relations; logical nature and structure of mathematics; introduction to number theory; algebra and geometry of complex numbers. Prereq: SYS. 3 u.

**110.1** **Abstract Algebra I.** Algebraic relations, lattices, Boolean algebra; groups; rings; integral domain. Prereq: Math 109. 3 u.

**110.2** **Abstract Algebra II.** Fields; vector spaces; linear transformations; matrices; characteristic values; diagonalization; inner product; quadratic forms. Prereq: Math 110.1. 3 u.

**110.3** **Abstract Algebra III.** Field of quotients of integral domains; polynomial rings; field extensions; other systems. Prereq: Math 110.1. 3 u.

**114** **Linear Algebra.** Vector spaces; linear transformations; matrices; eigenvalues; canonical forms; orthogonality; applications. Prereq: Math 54/equiv. 3 u.

**117** **Elementary Theory of Numbers.** Properties of integers; divisibility; unique factorization theorem; solutions of congruences; residue systems; primitive roots and the quadratic reciprocity law; solutions of Diophantine equations. Prereq: Math 109/COI. 3 u.

**121** **Elementary Differential Equations.** Ordinary differential equations of order one; linear differential equations; differential operators; Laplace Transforms; non-linear equations; series solutions about an ordinary point. Prereq: Math 54/equiv. 3 u.

**122** **Differential Equations and Applications.** Modeling systems; solutions of ordinary differential equations (ODE's) of order one and systems of ODE's; Laplace transform; solutions of the classical partial differential equations; numerical methods. Prereq: Math 65/equiv. 3 u.

**123.1** **Advanced Calculus I.** The real number system; point set topology; sequences of real numbers; limits and continuity; the derivative; the Riemann integral; series of real numbers; sequences and series of functions; uniform convergence; power series. Prereq: Math 65/equiv. 3 u.

**123.2** **Advanced Calculus II.** Topology of $R^n$; continuity, chain rule; Taylor's formula; implicit and inverse function theorems; multiple integration; improper integrals; transformations; metric and normed spaces. Prereq: Math 123.1. 3 u.

**126** **Real Analysis.** Properties of real numbers; integral of step functions; Lebesque integral; convergence theorems; measurable functions; measurable sets; selected topics. Prereq: Math 123.1. 3 u.

**128** **Complex Analysis.** Analytic functions; elementary functions; complex integration; power series; residues; conformal mapping. Prereq: Math 109/equiv., Math 123.1. 3 u.

**131** **Elementary Set Theory.** Axioms of Set Theory; relations and functions; natural numbers, cardinal numbers and the Axiom of Choice; orderings and ordinals. Prereq: Math 110.1. 3 u.

**140** **Introduction to Modern Geometries.** Development of modern geometries; finite geometries; geometric transformations; projective geometry; non-Euclidean geometries. Prereq: Math 109/equiv. 3 u.

**142** **Elementary Topology.** Topologies and topological spaces; functions and homeomorphisms; continuity; metric spaces; compactness and connectedness. Prereq: Math 123.1/COI. 3 u.

**146** **Introduction to Differential Geometry.** Elementary topology; calculus of several variables; curves and surfaces; theorems of Stokes and Gauss; differential forms. Prereq: Math 140, Math 65/equiv. 3 u.

**147** **Introduction to Algebraic Geometry.** Projective varieties; algebraic and elliptic curves. Prereq: Math 110.1, 140. 3 u.

**148** **Introduction to Projective Geometry.** Projective planes and spaces. Prereq: Math 110.1, 140. 3 u.

**150.1** **Mathematical Statistics I.** Combinatorial probability; probability distributions; joint and conditional distributions; random variables; distributions of functions of random variables; mathematical expectation; moment-generating functions; sampling distributions. Prereq: Math 65/equiv, Stat 101/equiv. 3 u.

**150.2** **Mathematical Statistics II.** Limiting distributions; estimation of parameters; tests of hypotheses; regression and correlation; analysis of variance; applications. Prereq: Math 150.1. 3 u.

**157** **Discrete Mathematical Structures.** Fundamentals of set theory; algebraic relations; combinatorial algorithms; algebraic structures and their applications in computer science. Prereq: Math 54. 3 u.

**162** **Theory of Interest.** Simple interest; compound interest; continuous interest; annuities; amortization schedules and sinking funds; bonds and other securities; special topics. Prereq: COI. 3 u.

**164** **Mathematics of Life Contingencies.** Mathematical theory of life contingencies involving single-life functions mortality; life annuities and insurances; reserves; the expense factor; population theory. Prereq: Math 150.1, 162/equiv. 3 u.

**171** **Introduction to Numerical Analysis.** Error analysis; solution of a single non-linear equation; solution of systems of equations; solution of ordinary differential equations; series. Prereq: Math 122/equiv, Math 110.2/equiv. 5 h. (2 lec, 3 lab) 3 u.

**180.1** **Operations Research I.** Review of classical optimization theory; introduction to linear programming,quadratic programming, non-linear programming and dynamic programming; networks (Path, PERT/CPM)and inventory problems. Prereq: Math 114/equiv. 3 u.

**180.2** **Operations Research II.** Review of probability theory; Stochastic models; Markov chains; introduction to queueing theory; introduction to simulation; games, replacement and reliability theory. Prereq: Math 180.1, Math 150.1. 3 u.

**196** **Undergraduate Seminar.** Prereq: Junior Standing. 1 u.

**197** **Special Topics.** Prereq: COI. 3 u (may be taken at most three times provided topics are different. Topics to be specified).

**200** **Undergraduate Thesis.** Prereq: SS. 3 u.

**GRADUATE**

**Mathematics (Math)**

**201** **Concepts and Techniques in Abstract Algebra.** Groups, rings and homomorphism. Prereq: Math 109/ COI. 3 u.

**202.1** **Analysis I.** Real numbers, sequences of real numbers and limits, continuity of functions, derivatives, Riemann integral. Prereq: COI. 3 u.

**202.2** **Analysis II.** n-dimensional Euclidean space, functions of several variables, partial derivatives, multiple integrals, complex-valued functions and their derivatives. Prereq: Math 202.1. 3 u.

**203** **Matrices and Applications.** Linear systems of equations and matrices, matrix operations, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, applications. Prereq: COI. 3 u.

**204** **Classical and Modern Geometry.** Finite geometries, euclidean and non-euclidean geometries, projective geometry, geometric transformations. Prereq: COI. 3 u.

**205** **Concepts and Methods in Probability and Statistics.** Descriptive statistics, probability and probability distributions, sampling theory, estimation and test of hypothesis, linear correlation and regression analysis. Prereq: COI. 3 u.

**208** **History and Development of the Fundamental Concepts of Mathematics.** Prereq: COI. 3 u.

**209.1** **Selected Topics in Applied Mathematics.** Prereq: COI. 3 u.

**209.2** **Selected Topics in Discrete Mathematics.** Prereq: Math 201. 3 u

**210.1** **Modern Algebra I.** Semigroups and groups; rings; fields; groups with operators. Selected topics. Prereq: COI. 3 u.

**210.2** **Modern Algebra II.** A continuation of Mathematics 210.1. Prereq: Math 210.1. 3 u.

**211** **Linear Algebra.** Vector spaces, linear mappings; theorem of Hamilton-Cayley; modules over principal ideal domains; Jordan canonical form, rational canonical form; bilinear forms, inner products; law of inertia, spectral theorem; multilinear forms; tensor products. Prereq: Math 110.2/114/COI. 3 u.

**212** **Theory of Groups.** Prereq: COI. 3 u.

**213** **Theory of Rings.** Prereq: COI. 3 u.

**214** **Theory of Matrices.** Prereq: COI. 3 u.

**216** **Lie Groups and Lie Algebras.** Classical matrix Lie groups, Lie algebras of Lie groups, nilpotent and solvable algebras, semisimple algebras, representations. Prereq: Math 210.1. 3 u.

**217** **Theory of Numbers.** Linear Congruences, Euler's and Wilson's Theorems, Quadratic residues, Quadratic Reciprocity Law, Jacobi's and Kronocker's symbols, Polian Equation, Positive Binary and Ternary quadratic forms. Theory of the sums of two and three squares. Prereq: COI. 3 u.

**218** **Theory of Algebraic Numbers.** Algebraic number fields; algebraic integers; basic and discriminant; ideals; fundamental theorem on the decomposition of ideals; ideal classes; Minkowski's theorem; the class formula; units; Fermat's last theorem. Selected topics. Prereq: COI. 3 u.

**220.1** **Theory of Functions of a Real Variable I.** Lebesgue and other integrals; differentiation; measure theory. Prereq: Math 123.1, COI. 3 u.

**220.2** **Theory of Functions of a Real Variable II.** Continuation of Math 220.1. Selected topics. Prereq: Math 220.1. 3 u.

**221** **Partial Differential Equations.** Equations of the first and second order. Green's function. Boundary value problems. Prereq: COI. 3 u.

**222** **Approximation Theory.** Taylor's theorem, Weierstrass approximation theorem, approximation in Hilbert spaces, Fourier Series and Fourier transform, direct and inverse theorems, algebraic and trigonometric interpolation, Whittaker-Shannon sampling theory, wavelet analysis. Prereq: Math 220.1/COI. 3 u.

**224** **Control Theory.** Elements of the calculus of variations. Naive optimal control theory; Functional analysis; Generalized optimal control theory; The Pontrjagin maximum principle for chattering controls; Research problems. Prereq: Math 126, 142/COI. 3 u.

**227** **Calculus of Variation.** Euler's equations. Legendre conditions. Jacobi's conditions. Isoperimetric problems. Lagrange's methods. Dirichlet's principle. Prereq: COI. 3 u.

**228** **Theory of Functions of a Complex Variable.** Analytic functions; geometric function theory; analytic continuation; Riemann Mapping Theorem. Prereq: COI. 3 u.

**229** **Functional Analysis.** Linear operators, linear functionals, topological linear spaces, normed spaces, Hilbert spaces, functional equations, Radon measures, distributive and linear partial differential equations, and spectral analysis. Prereq: Math 220.1. 3 u.

**235** **Mathematics in Population Biology.** Continuous and discrete population models for single species, models for interacting populations, evolutionary models, dynamics of infectious diseases. Prereq: Math 121.1/equiv/COI. 3 u.

**236** **Mathematics in Biological Processes.** Biological oscillators and switches, perturbed and coupled oscillators, reaction diffusion, enzyme kinetics, chemotaxis, circadian systems models, coupled cell networks. Prereq: COI. 3 u.

**240** **Geometric Crystallography.** Isometries, frieze groups, crystallographic groups, lattices and invariant sublattices, finite groups of isometries, geometric and arithmetic crystal classes. Prereq: Math 210.1/ equiv. 3 u.

**241** **Hyperbolic Geometry.** Moebius transformations, hyperbolic plane and hyperbolic metric, geometry of geodesics, hyperbolic trigonometry, groups of isometries on the hyperbolic plane. Prereq: Math 210.1/equiv. 3 u.

**242** **General Topology.** Topological spaces; metric spaces; theory of convergence; bases; axioms of countability; subspaces; homeomorphisms. Selected topics. Prereq: COI. 3 u.

**243** **Algebraic Topology.** Homotopy, fundamental group, singular homology, simplicial complexes, degree and fixed point theorems. Prereq: Math 242. 3 u.

**246** **Differential Geometry.** Classical theory of curves and surfaces. Mappings of surfaces. Differential structures. Lie groups and frame bundles. Prereq: Math 123.2/COI. 3 u.

**247** **Algebraic Geometry.** The general projective space. Collineation and correlations in a projective space. Algebraic manifolds. Plane curves. Quadratic transformation of systems of plane curves. Prereq: COI. 3 u.

**249** **Selected Topics in Geometry and Topology.** Prereq: COI. 3 u.; topic to be specified for record purposes.

**250** **Probability Theory.** Random variables, laws of large numbers, special probability distributions, central limit theorem, Markov chains, Poisson process, martingales. Prereq: Math 220.1/COI. 3 u.

**255** **Mathematics of Decision Making.** Some application of Bayesian statistics; use of experiments in decision problems; group decision making and risk-sharing. Prereq: Math 155. 3 u.

**258** **Combinatorial Mathematics.** Permutations and combinations. Generating functions. Principle of inclusion and exclusion. Recurrence relations. Occupancy. Matrices of zeros and ones. Partitions. Orthogonal Latin squares. Combinatorial designs. Prereq: COI. 3 u.

**260** **Actuarial Theory and Practice.** Multiple life theory, multiple decrement theory, applications of multiple decrement theory, risk theory, ruin theory and introduction to credibility theory. Prereq: Math 164/COI. 3 u.

**261** **Survival and Loss Models.** Hazard rate function, analysis of various survival and loss models, credibility theory. Prereq: Math 164/COI. 3 u.

**262.1** **Actuarial Science I.** Gross premiums and asset shares, non forfeiture values, expense analysis, distribution of surplus, valuation of liabilities, product development process, introduction to life insurance accounting. Prereq: Math 261/ COI. 3 u.

**262.2** **Actuarial Science II.** Selection of risks, reinsurance, introduction to investments analysis and finance management, insurance code, actuarial principles in special lines of insurance. Prereq: Math 262.1/ COI. 3 u.

**265** **Stochastic Calculus.** Conditional expectations, martingales, Brownian motion, Ito integral, Ito formula, stochastic differential equation, Girsanov Theorem, applications to mathematical finance. Prereq: Math 150.1/COI. 3 u.

**266** **Mathematical Finance.** Binomial asset pricing model, vanilla options, exotic options, American options, arbitrage probabilities, profit and loss, stochastic interest rates. Prereq: Math 265/COI. 3 u.

**271.1** **Numerical Analysis I.** Floating point representation, condition numbers, iterative methods for solving systems of linear and non-linear equations, numerical integration, numerical linear algebra. Prereq: Math 171/COI. 3 u.

**271.2** **Numerical Analysis II.** Numerical methods for ordinary differential equations, finite-difference methods for partial difference equations, numerical methods for conservation laws, multi-grid methods. Prereq: Math 271.1/COI. 3 u.

**272** **Automata Theory.** Finite state automata. Regular expressions, decomposition of finite automata and their realization. Turing machines. Introduction to formal languages. Prereq: COI. 3 u.

**276** **Introduction to Computer Simulation.** Introduction to computer simulation of theoretical system and real-time processes. Examples of simulation for the solution of both theoretical and practical problems in various fields of application. Prereq: COI. 3 u.

**280** **Linear Programming.** Simplex method, duality, geometry of linear programs, parametric programming, decomposition and upper-bounded variables. Prereq: Math 114, 180.2. 3 u.

**281** **Nonlinear Programming.** Properties of convex sets and functions. Unconstrained optimization. Kuhn- Tucker Theorem. Lagrange Multipliers. Saddle-point Theorems. Algorithms. Prereq: COI. 3 u.

**282** **Integer Programming and Combinatorial Optimization.** Applications of integer programming. Converging dual and primal cutting plane algorithms. Branch-bound methods. Total unimodularity and the transportation problem. Applications of graph theory to mathematical programming. Prereq: Math 280/equiv. 3 u.

**283** **Applied Dynamic Programming.** Deterministic decision problems; Analytical and computational methods; Applications to problems of equipment replacement, resource allocation, scheduling, search and routing. Prereq: GS/COI. 3u.

**285** **Introduction to Stochastic Optimization.** Probability theory and applications to discrete and continuous time Markov chains; classification of states; algebraic methods, birth and death processes, renewal theory, limit theorems. Prereq: Math 114, 150.1. 3 u.

**286** **Finite Graphs and Networks.** Basic graph theory and applications to optimal path problems; flows in network; combinatorial problems. Prereq: Math 285/COI. 3 u.

**288** **Numerical Optimization.** Deterministic descent type methods, stochastic optimization methods, numerical implementation. Prereq: Math 271.1/COI. 3 u.

**290** **Research Paper on College Mathematics.** Prereq: COI. 3 u.

**294** **Independent Study.** May be credited once in the M.S. Mathematics/Applied Mathematics programs and twice in the Ph.D. Mathematics program. 3 u.

**295** **Special Project.** Prereq: COI. 3 u.

**296** **Graduate Seminar.** Prereq: COI. 1 u.

**297** **Special Topics.** Prereq: COI. 3 u.; topic to be specified for record purposes.

**300** **Master's Thesis.** 6 u.

**400** **PhD Dissertation.** 12 u.

## INSTITUTE OF ENVIRONMENTAL SCIENCE & METEOROLOGY

### GENERAL EDUCATION COURSE

**Environmental Science (Env Sci)**

**1[a]** **Environment and Society.** Introduction to principles and concepts in the study of the natural environment within a societal framework. 3 u.

### GRADUATE

**Environmental Science (Env Sci)**

**201** **Fundamentals of Environmental Science I.** The earth's environment in terms of the properties, structures and processes interrelationships of the atmosphere, lithosphere, hydrosphere and the biosphere. Prereq: COI. 3 u.

**202** **Fundamentals of Environmental Science II.** Tropical ecosystems such as marine, estuarine, lakes and rivers, forest, island and urban ecosystems. Prereq: COI. 3 u.

**211** **Computational Methods in Environmental Science.** Mathematical, statistical and computer methods in environmental science. Prereq: COI. 3 u.

**212** **Environmental Problems and Issues.** Current and prospective environmental problems and issues of critical concern in the context of sustainable development and other management development strategies. Prereq: COI. 3 u.

**221** **Environmental Biology.** Biological aspects of environmental science. Prereq: COI. 3 u.

[a] *Math, Science and Technology domain*

**225.1** **Terrestrial Ecology Sampling Techniques.** Prereq: COI. 1 u.

**226.1** **Aquatic Ecology Sampling Techniques.** Prereq: COI. 1 u.

**227** **Quantitative Ecology.** Biological modeling at the population, community and ecosystem levels; quantitative analysis of ecological patterns in time and space. Prereq: Env Sci 201/COI. 3 u.

**228** **Environmental Biotechnology.** The applications of biotechnology in environmental monitoring, assessment and management. Prereq: COI. 3 u.

**232.1** **Water Quality Sampling Techniques.** Prereq: COI. 1 u.

**233** **Environmental Toxicology.** Xenobiotics in the environment; their sources, pharmacodynamics, mode of action and detoxification. Prereq: COI. 3 u.

**241** **Geological Hazards.** Study of common geological hazards and their environmental effects. Prereq: COI. 3 u.

**262** **Water Quality Modeling.** Principles and techniques of modeling water quality in aquatic systems. Prereq: Env Sci 201/COI. 5 h. (2 lec, 3 lab) 3 u.

**263.1** **Air Quality Sampling Techniques.** Prereq: COI. 1 u.

**265** **Applications of Remote Sensing to Environmental Science.** Applications of remote sensing techniques to environmental monitoring, assessment and planning. Prereq: COI. 3 u.

**265.1** **Remote Sensing Techniques. Prereq: COI. 1 u.**

**271** **Principles of Photonic Techniques for Environmental Monitoring.** Light as a probe for nondestructive analysis; optical signal processing and image analysis. Prereq: COI. 3 u.

**271.1** **Photonic Techniques.** Prereq: COI. 1 u.

**282** **Environmental Planning, Risk and Impact Assessment.** Framework and techniques of environmental planning, risk and impact assessment; the Philippine Environmental Impact Statement (EIS) system.

**296** **Seminar.** Prereq: COI. 1 u.

**297** **Special Topics.** Prereq: COI. 1-3 u.

**299** **Independent Masteral Study.** Prereq: COI. 3 u.

**300** **Masteral Thesis.** Prereq: Consent of Program Adviser. 6 u.

**399** **Independent Doctoral Study. Prereq: COI. 3 u.**

**400** **Doctoral Dissertation.** Prereq: Consent of Program Adviser. 12 u.

## UNDERGRADUATE

### Meteorology (Meteo)

**101** **General Meteorology.** The atmosphere and its circulation; radiation and heat exchanges; weather disturbances; elementary climatology. Prereq: Physics 72/COI. 3 u.

## GRADUATE

### Meteorology (Meteo)

**201** **Synoptic Meteorology.** Mesoscale to planetary scale weather systems of the general circulation with emphasis on synoptic scale systems. Prereq: COI. (3 u [3h lec], 1 u [3h lab]). 4 u.

**202** **Synoptic Meteorology Practicum.** Summer practical work at the Weather Forecasting Office. Prereq: Meteo 201. 9 h. (lab) 3 u.

**203** **Methods of Analytical Meteorology and Oceanography.** Mathematical and numerical methods in meteorology and oceanography; principles of statistical analysis; computer programming. Prereq: Math 55/equiv/COI. (2 u [2h lec], 1 u [3h lab]. 3 u.

**204** **Tropical Meteorology.** Low latitude dynamics; survey of tropical disturbances; development, structure and movement of tropical cyclones. Prereq: Meteo 201, 232. 3 u.

**205** **Atmospheric Science for Teachers.** A qualitative course in meteorology designed for science teachers. Prereq: COI. 3 u.

**206** **Hydrometeorology.** Integration of hydrology and meteorology focusing on precipitation, surface flow, and groundwater flow, and their observation, analysis, modeling, and forecasting. Prereq: Meteo 201. (2u [2h lec], 1 u [3h lab]). 3 u.

**211** **Climatology.** Climate and climate systems including integration of dynamic, physical, biogeochemical, and anthropogenic bases of climate and climate systems. Prereq: COI. 3 u.

**212** **Climate Monitoring and Prediction.** Analysis of climate data, its application and utility in global climate models; climate monitoring principles; statistical and dynamical techniques; climate modeling and parameterization; coupling and interactions. Prereq: Meteo 211. (2 u [2h lec], 1 u [3h lab]). 3 u.

**213** **Agrometeorology.** Implications of meteorological processes to agriculture including soil and heat balance, hydrological cycle, small-scale climate, agrometeorological management at microscale and topscale, and operational agrometeorology. Prereq: Meteo 211. (2 u [2h lec], 1 u [3h lab]. 3 u.

**221** **Physical Meteorology.** Fundamentals of physical atmospheric processes with emphasis on the thermodynamics of the atmosphere and principles of radiative transfer. Prereq: COI. (3 u [3h lec], 1 u [3h lab]). 4 u.

**222** **Satellite Meteorology.** Principles and applications of remote sensing technology to meteorology; nature of radiation, absorption, emission, reflection and scattering, radiative transfer equation, surface temperature, and cloud detection; satellite observations; data acquisition, handling, and processing; interpretation of satellite data. Prereq: Meteo 221 (for MS Meteorology majors). (2 u [2h lec], 1 u [3h lab]). 3 u.

**223** **Radar Meteorology.** Principles and applications of radar to meteorology; radar systems; radar data acquisition, handling and processing; integration of radar principles to synoptic and dynamic processes in the atmosphere. Prereq: Meteo 201 (for MS Meteorology majors). (2 u [2h lec], 1 u [3h lab]). 3 u.

**224** **Air Pollution Meteorology.** Interrelationship between meteorology and air pollution; role of contaminants in climate change and stratospheric ozone depletion; dispersion modeling; legislations and mitigations. Prereq: COI. (2 u [2h lec], 1 u [3h lab]). 3 u.

**225** **Cloud and Precipitation Physics.** Dynamics and microphysical processes of cloud and rain formation, modeling and parameterization, and cloud modification. Prereq: Meteo 221. 5 h. (2 lec, 3 lab) 3 u.

**231** **Dynamic Meteorology.** Fundamentals of fluid dynamics, physical laws of conservations of mass, momentum, and energy applied to various horizontal and vertical scale motions; circulation and vorticity. Prereq: Meteor 221. 3 u (3h lec), 1 u (3h lab). 4 u.

**232** **Advanced Dynamic Meteorology.** Fluid dynamics applied to atmospheric flows over synoptic scale motions, mesoscale and general circulations, and tropical and middle atmospheric dynamics. Prereq: Meteor 232. 3 u.

**233** **Geophysical Fluid Dynamics.** Kinematics of fluid flow on a rotating sphere such as fundamental dynamics, barotropic and vortex dynamics, rotating shallow-water and wave dynamics, baroclinic and jet dynamics, and boundary-layer and wind-gyre dynamics. Prereq: COI. 3 u.

**234** **Numerical Weather Prediction.** Examination, evaluation and application of numerical models for weather diagnosis and forecasting. Prereq: Meteo 221, 231. (3u [2h lab], 1 u [3h lab]). 3 u.

**296** **Graduate Seminar.** Prereq: Completion of all core courses. 1 u.

**297** **Special Topics.** Prereq: COI. 3 u.

**300** **M.S. Thesis.** Prereq: Completion of all course requirements. 6 u.

**321** **Research Problems in Physical Meteorology.** Prereq: Meteor 221. 3 u.

**331** **Research Problems in Dynamic Meteorology.** Prereq: Meteor 232. 3 u.

**341** **Research Problems in Tropical Meteorology.** Prereq: Meteor 241. 3 u.

**396** **Research Seminar.** Prereq: Completion of all core courses. 1 u.

**399** **Independent Doctoral Study.** Prereq: Completion of all core courses. 3 u.

**400** **PhD Dissertation.** Prereq: Passing of candidacy examination and completion of all course requirements. 12 u.

## NATIONAL INSTITUTE OF MOLECULAR BIOLOGY AND BIOTECHNOLOGY

### GENERAL EDUCATION COURSE

#### Molecular Biology and Biotechnology (MBB)

**1**[a] **Biotechnology and You.** Historical events, processes, products, issues and concerns in modern biotechnology. 3 u.

### UNDERGRADUATE

#### Molecular Biology and Biotechnology (MBB)

**10** **Introduction to Molecular Biology.** An introduction to the fundamentals of molecular biology and biotechnology. 2 u.

**100** **Introduction to Scientific Writing in Molecular Biology and Biotechnology.** Principles and methods in scientific writing in molecular biology and biotechnology. Prereq: Sophomore standing, COI. 3 u.

**110** **Fundamentals of Molecular Microbiology.** Molecular diversity, physiology and genetics of microorganisms. Prereq: MBB 10, BIO 12. 8 h. (2 lec, 6 lab) 4 u.

**121** **Fundamentals of Cell and Tissue Culture.** Principles and methods in plant and animal cell culture. Prereq: MBB 10, BIO 12, Chem 40, 40.1/equiv. 5 h. (2 lec, 3 lab). 3 u.

**125** **Molecular Physiology of Eukaryotic Systems.** Molecular mechanisms of eukaryotic cell processes. Prereq: MBB 10, BIO 12, Chem 40, 40.1. 9 h. (3 lec, 6 lab) 5 u.

**130** **Molecular Biophysics.** Characterization of biomolecules and their interactions through structural analysis and computational techniques. Prereq: Math 55, Chem 40, Chem 40.1, Physics 72. 6 h. (3 lec, 3 lab) 4 u.

**140** **Molecular Genetics.** Principles and mechanisms of heredity at the molecular level based on studies of prokaryotic, eukaryotic and viral systems. Prereq: MBB 10, BIO 12, Chem 40, 40.1. 3 u.

[a] *Math, Science and Technology domain*

**141** **Principles of Gene Manipulation.** Principles of recombinant DNA technology and its applications. Prereq: MBB 140. 9 h. (3 lec, 6 lab) 5 u.

**142** **Genes and Development.** Molecular and genetic mechanisms underlying multicellularity during embryogenesis and formation of the body plan in model organisms. Prereq: MBB 125, 130, 141. 9 h. (3 lec, 6 lab). 5 u.

**150** **Cellular and Molecular Immunology.** Cellular and molecular aspects of the immune response. Prereq: Chem 40, 40.1, MBB 125. 3 u.

**180** **Industrial Biotechnology.** Principles and applications of traditional methods and novel molecular biology techniques in making useful industrial products. Prereq: MBB 110, MBB 121, MBB 141. 9 h. (3 lec, 6 lab). 5 u.

**190** **Introduction to Bioinformatics and Systems Biology.** Basic concepts of systems biology and the application of computational analysis in molecular biology. Prereq: MBB 130, MBB 140. 5 h. (2 lec, 3 lab). 3 u.

**194** **Ethics in Scientific Research.** Discussion of case studies and topics pertaining to social issues and the proper conduct of scientific research relevant to molecular biology. Prereq: JS. 1 u. with a grade of pass or fail.

**195** **Biotechnology Enterprise.** Fundamentals of biotechnology commercialization and entrepreneurship. Prereq: Senior standing, COI. 3 u.

**196** **Undergraduate Seminar.** Prereq: SS. 1 u.

**197** **Special Topics in Molecular Biology and Biotechnology.** Current trends and concepts in molecular biology and biotechnology. Prereq: SS. 3 u.

**200** **Undergraduate Thesis.** Prereq: SS. 2 u. per sem. for a total of 4 u.

**GRADUATE**

**Molecular Biology and Biotechnology (MBB)**

**215** **Molecular Biology of Viruses.** Concepts and molecular studies on viral composition, growth, and effects on cellular processes. Prereq: MBB 110/equiv. 3 u.

**221** **Advances in Cell and Tissue Culture.** Advances in plant and animal tissue culture and their application to various areas of biotechnology. Prereq: MBB 121/equiv. 3 u.

**222** **Molecular Basis of Growth Regulation.** Mode of action of growth substances at the molecular and cellular levels. Prereq: COI. 3 u.

**225** **Advanced Molecular Physiology.** Molecular mechanisms involved in the physiology of biological systems. Prereq: MBB 125/equiv. 3 u.

**230** **Principles of Instrumentation in Molecular Biology.** Principles of instrumentation employed in the study of the properties of biomolecules using physical and molecular probes. Prereq: MBB 130/equiv. 3 u.

**241** **Advances in Genetic Engineering.** Advances in recombinant DNA technology, biomolecular analyses, and their applications. Prereq: MBB 141/equiv. 3 u.

**242** **Mammalian Embryology and Genetics.** Mammalian embryogenesis and the genetic basis of developmental programs that give rise to multicellularity during cell and organ differentiation. Prereq: COI. 3 u.

**260** **Food and Agricultural Biotechnology.** Principles of genetic manipulation applied to crops and livestock. Prereq: COI. 3 u.

**280** **Advances in Microbial Biotechnology.** Recent developments in microbial biotechnology with emphasis on the molecular techniques and mechanisms involved in the synthesis of various economically important products. Prereq: MBB 110/ equiv. 3 u.

**289** **Advanced Techniques in Molecular Biology and Biotechnology.** Advanced laboratory techniques and applications in molecular biology and biotechnology research. Prereq: COI. 9 h (lab). 3 u.

**294** **Ethics in Research.** Ethical issues in the conduct of scientific research. Prereq: COI. 1 h (lec; Pass/Fail). 1 u.

**296** **Graduate Seminar.** 1 u; may be taken twice.

**300** **MS Thesis.** Prereq: Completion of all course requirements. 6 u.

**310** **Molecular Basis of Pathogenesis.** Molecular mechanisms of attachment, invasion, cell damage, and host cell interaction of pathogens. Prereq: COI. 3 u.

**315** **Molecular Biology of Extremophiles.** Diversity of genomes and proteins of extremophiles and their potential for industrial applications. Prereq: COI. 3 u.

**325** **Molecular Plant Pathology.** Plant infectious agents and vectors; molecular basis of their attachment, invasion, cell damage, and host cell interaction.Preeq: COI. 3 u.

**340** **Human Molecular Genetics.** Principles and mechanisms of human genetic variation at the molecular level; techniques in human genome analysis. Prereq: MBB 140/equiv. 3 u.

**350** **Advanced Cellular and Molecular Immunology.** Cellular and molecular mechanisms of immune system activation,

regulation and function and their consequences in health and disease. Prereq: MBB 150/equiv. 3 u.

**380** **Molecular Diagnostics.** Fundamental concepts and applications of molecular methods in the detection, identification, and prediction of infectious agents in plants and animals. Prereq: COI. 3 u.

**390** **Bioinformatics and Systems Biology.** Computational methods to study biological systems; the interactions of key elements such as genes, proteins and other cell components that give rise to function and behavior of a system. Prereq: MBB 130/ equiv, MBB 140/equiv. 5 h (2 lec, 3 lab). 3 u.

**397** **Current Topics in Molecular Biology and Biotechnology.** Recent developments in molecular biology and biotechnology. Prereq: COI. 3 u.; may be repeated for additional credits, topic to be indicated for record purposes.

**398** **Special Problems in Molecular Biology and Biotechnology.** Design and conduct of experiments with data analyis to address a specific scientific question in MBB. Prereq: MBB 241/equiv, MBB 280/ equiv. 7 h. (1 lec, 6 lab). 3 u.; may be taken more than once for additional credits, topic to be indicated for record purposes.

**400** **PhD Dissertation.** Prereq: Passing candidacy examination and completion of all course requirements. 12 u.

## NATIONAL INSTITUTE OF PHYSICS

### UNDERGRADUATE

#### Applied Physics (App Physics)

**155** **Computer Methods in Physics I.** Number systems and number representations; overview of computer hardware and software; computer programming methods; numerical analysis; research data processing; introduction to simulation and modeling. Prereq: Math 121.1. 6 h. (3 lec, 3 lab) 4 u.

**156** **Computer Methods in Physics II.** Advanced computer programming methods; numerical modeling and simulations; discrete models; stochastic methods; current approaches in numerical modeling. Prereq: App Physics 155. 6 h. (3 lec, 3 lab) 4 u.

**171** **Introductory Crystallography.** Properties and symmetries of crystals; x-ray diffraction; interpretation of diffraction patterns; methods of determining the crystal structure of various substances. Prereq: Physics 105/equiv. 5 h. (2 lec, 3 lab) 3 u.

**173** **Solid State Physics.** Crystal structure of solids; lattice vibrations; band theory of solids; metals; semiconductor materials and devices; dielectric, magnetic, thermal, optical, and mechanical properties of solids; superconductors. Prereq: Physics 105. 3 u.

**175** **Materials Physics I.** Fabrication, processing, characterization, and applications of selected semiconductor, dielectric, magnetic, metallic, superconducting, and photonic materials. Prereq: App Physics 173. 3 u.

**176** **Materials Physics II.** Fabrication, processing, characterization, and applications of amorphous materials, liquid crystals, polymers, ceramic, composites, and other important new materials. Prereq: App Physics 175. 3 u.

**181**[a] **Physical Electronics I.** Analysis of passive circuits; resonance and filters; semiconductor theory; noise theory; semiconductor devices and their applications; operational amplifiers and analog electronics; FET, MOSFET, CMOS, integrated circuits; electronic instrumentation. Prereq: Physics 104. 6 h. (3 lec, 3 lab) 4 u.

**182**[a] **Physical Electronics II.** Digital theory; logic and switching ciruits; analog–digital conversion and multiplexing; computer hardware and interfacing; microprocessors and machine language programming; applications of microprocessors. Prereq: App Physics 181. 6 h. (3 lec, 3 lab) 4 u.

**183** **Control Systems Approach to Physics Modeling.** Linear and nonlinear systems; analog and digital control systems; time-domain modeling; frequency-domain modeling; transient response, stability analysis, steady-state error; control system design. Prereq: Physics 121. 3 u.

**185**[a] **Instrumentation Physics I.** Sensors, transducers, and measurement techniques for various physical variables; signal conditioning, digitization and sampling; signal processing and reliability of data. Prereq: App Physics 182, Physics 191. 6 h. (3 lec, 3 lab) 4 u.

**186**[a] **Instrumentation Physics II.** Imaging systems and image processing; multidimensional detection techniques; pattern recognition. Prereq: Physics 165, App Physics 185. 6 h. (3 lec, 3 lab) 4 u.

**187** **Photonics and Applied Optics.** Design of Data Acquisition Systems (DAQ)/Signal Processing-based instrumentation systems; current topics and techniques for engineering and design of optical instruments; non-destructive testing/ measurement using optical methods; interferometry. Prereq: App Physics 185, Physics 166; Coreq: App Physics 186. 6 h. (3 lec, 3 lab) 4 u.

**195** **Special Topics.** Selected topics of current interest in applied physics. Prereq: COI. 3 u.

**199** **Undergraduate Research.** Prereq: COA. (satisfactory-or-unsatisfactory basis). 3 u.

**200** **Undergraduate Thesis.** (satisfactory-or-unsatisfactory basis). 3 u.

[a] *This is part of a two-semester course*

## GENERAL EDUCATION COURSE

### Physics

**10**[a] **Physics and Astronomy for Pedestrians.** A "walk-through" course for people who want to enjoy physics and astronomy. 3 u.

## UNDERGRADUATE

### Physics

**71** **Elementary Physics I.** Mechanics of particles, rigid bodies, and fluids. Coreq: Math 53/Math 100. (3 lec, 1 discussion) 4 u.

**71.1** **Elementary Physics I Laboratory.** Coreq: Physics 71. 2 h. (lab) 1 u.

**72** **Elementary Physics II.** Electricity and magnetism, wave phenomena, and optics. Prereq: Physics 71. 4 h. (3 lec, 1 discussion) 4 u.

**72.1** **Elementary Physics II Laboratory.** Prereq: Physics 71.1; Coreq: Physics 72. 2 h. (lab) 1 u.

**73** **Elementary Physics III.** Thermal physics, relativity, and quantum physics. Prereq: Physics 72. 4 h. (3 lec, 1 discussion) 4 u.

**73.1** **Elementary Physics III Laboratory.** Prereq: Physics 72.1; Coreq: Physics 73. 2 h. (lab) 1 u.

**101** **Fundamental Physics I.** Fundamentals of Newtonian mechanics and gravitational theory. Coreq: Math 53/equiv. 4 u.

**101.1** **Fundamental Physics I Laboratory.** Coreq: Physics 101. 3 h. (lab) 1 u.

**102** **Fundamental Physics II.** Fundamentals of electromagnetism and special relativity. Prereq: Math 54; Physics 101, 101.1/71, 71.1. Coreq: Math 55. 4 u.

**102.1** **Fundamental Physics II Laboratory.** Coreq: Physics 102. 3 h. (lab) 1 u.

**103** **Fundamental Physics III.** Fundamentals of waves, optics, and thermal physics. Prereq: Math 55, Physics 102, 102.1/equivs; Coreq: Math 121.1. 4 u.

**103.1** **Fundamental Physics III Laboratory.** Coreq: Physics 103. 3 h. (lab) 1 u.

**104**[b] **Modern Physics I.** The old quantum theory up to the Bohr-Sommerfeld model; Schroedinger's equation and elementary wave mechanics; one-electron atoms; multi-electron atoms; Pauli's exclusion principle. Prereq: Physics 103, Math 121.1/equiv. 4 u.

**104.1** **Modern Physics I Laboratory.** Coreq: Physics 104. 3 h. (lab) 1 u.

**105**[b] **Modern Physics II.** Introduction to the physics of x-rays, molecules, lasers, condensed matter, nuclei, and fundamental particles. Prereq: Physics 104. 3 u.

**111**[b] **Mathematical Physics I.** Abstract linear spaces and operators; matrix algebra; vector analysis; cartesian tensors and elementary differential geometry. Coreq: Math 55. 3 u.

**112**[b] **Mathematical Physics II.** Complex analysis; differential equations and special functions; Fourier series and transforms. Prereq: Physics 111; Coreq: Math 121.1. 3 u.

**113** **Mathematical Physics III.** Sturm-Liouville theory; normed linear spaces, inner product space, Hilbert space and linear operators; integral equations and Green functions, functional derivatives; probability and statistics, random variables and random processes. Prereq: Physics 112. 3 u.

**114** **Mathematical Physics IV.** Topology, topological spaces, metric spaces; differential forms; introduction to group theory including finite and continuous groups, group representations, Lie groups. Prereq: Physics 113. 3 u.

**121**[b] **Theoretical Mechanics I.** Principles of Newtonian mechanics, the Newtonian theory of gravitation, impulse and collisions, constrained motion, Lagrangian dynamics, central-force motion, linear and nonlinear oscillations. Prereq: Physics 103; Coreq: Physics 113. 3 u.

**122**[b] **Theoretical Mechanics II.** Motion in non-inertial frames, relativistic mechanics, mechanics of rigid bodies, systems of small coupled oscillations, vibrating strings and one-dimensional waves, introduction to fluid mechanics. Prereq: Physics 121. 3 u.

**131**[b] **Electromagnetic Theory I.** Electrostatics in a vacuum, electrostatics in dielectric media, boundary value methods in electrostatics, electric currents, conducting media, magnetostatics in a vacuum, macroscopic and microscopic magnetism, Faraday's law of electromagnetic induction. Prereq: Physics 103; Coreq: Physics 113. 3 u.

**132**[b] **Electromagnetic Theory II.** Maxwell's equations, special relativity and electrodynamics, motion in static electromagnetic fields, the Lienard-Wiechert fields, electromagnetic radiating systems, propagation of electromagnetic waves, wave guides and cavity resonators, classical electron theory. Prereq: Physics 131. 3 u.

**135** **Introductory Plasma Physics.** Fundamental processes of ionization and deionization, basic properties of plasmas, particle orbits in electromagnetic fields, continuum model of a plasma, waves in cold plasmas, thermonuclear reactions and plasma devices. Prereq: Physics 132. 3 u.

[a] *Math, Science and Technology domain*

[b] *This is part of a two-semester course*

**141**[a] **Quantum Physics I.** Wave packets and uncertainty principle, the Schroedinger equation, simple one-dimensional systems, three-dimensional systems, quantum particle in an external field, the postulates and mathematical formalism of quantum mechanics. Prereq: Physics 104, 112. 3 u.

**142**[a] **Quantum Physics II.** Spin, identical particles, WKB approximation, time-independent, perturbation theory, scattering theory, time-dependent perturbation theory, canonical quantization, introduction to path integrals. Prereq: Physics 113, 141. 3 u.

**151** **Statistical Physics I.** Review of thermodynamics, basic statistical concepts, basic methods of statistical mechanics, canonical and grand canonical ensembles, some applications of statistical mechanics, quantum statistics of ideal gases. Prereq: Physics 121. 3 u

**152** **Statistical Physics II.** Applications of quantum statistics of ideal gases, elementary kinetic theory of transport processes, Boltzmann equation in the absence of collision, path-integral formulation; general Boltzmann equation; transition probabilities, master equation, Fokker-Planck equation and its applications. Prereq: Physics 151. 3 u.

**161** **Introductory Laser Physics.** Intensity equation for light propagation in a medium, Einstein's theory of light-matter interaction, gain saturation and dispersive effects in lasers, laser amplification and oscillation, optical resonators and optical modes, general properties and applications of lasers. Prereq: Physics 104. 3 u.

**165** **Optical Physics I.** Wave theory, geometrical optics, polarization, interference and diffraction. Prereq: Physics 132. 3 u.

**166** **Optical Physics II.** Coherence theory; Fourier optics and imaging; basic microscopy; spectroscopy; nonlinear optics. Prereq: Physics 165. 3 u.

**170** **Condensed Matter.** Crystal structure; mechanical, thermal, electric, and magnetic properties of solids; band theory of solids; metals, insulators, and semiconductors; lattice vibrations; imperfections; superconductivity and superfluidity. Coreq: Physics 105/142. 3 u.

**180** **Nuclei and Particles.** Basic nuclear properties and classification of fundamental particles; symmetries and invariance principles; strong, weak, and electromagnetic interactions; SU (3), quarks, and other selected topics. Prereq: Physics 142. 3 u.

**191**[a] **Experimental Physics I.** Selected standard experiments in modern physics with accompanying lectures on basic experimental techniques and advanced data analysis as well as practical work in technical drawing and machine shop operations. Prereq: App Physics 181, Applied Physics 155. (3 lec, 6 lab) 5 u.

**192**[a] **Experimental Physics II.** Selected advanced experiments and projects in modern physics with accompanying lectures on advanced experimental techniques, experimental design, and instrumentation. Prereq: Physics 191. 7 h. (1 lec, 6 lab) 3 u.

**195** **Special Topics.** Selected topics of current interest in modern physics. Prereq: COI. 3 u.

**196** **Undergraduate Seminar.** Prereq: SS. 1 u.

**199** **Undergraduate Research.** Prereq: COI. (satisfactory-or-unsatisfactory basis). 3 u.

**200** **Undergraduate Thesis.** (satisfactory-or-unsatisfactory basis). 3 u.

## GRADUATE

### Physics

**201**[b] **Foundations of Mathematical Physics.** Abstract linear spaces and operators, matrix algebra, vector and tensor analysis. Prereq: COI. 3 u.

**202.1**[a,b] **Foundations of Mechanics I.** Principles of Newtonian mechanics, the Newtonian theory of gravitation, collisions, systems with constraints, Lagrangian formulation, central-force motion, linear and nonlinear oscillations. Prereq: COI. 3 u.

**202.2**[a,b] **Foundations of Mechanics II.** Motion in non-inertial frames, relativistic mechanics, rigid body dynamics, small oscillations, one-dimensional waves, introduction to fluid mechanics. Prereq: Physics 202.1. 3 u.

**203.1**[a,b] **Foundations of Electromagnetism I.** Electrostatics in free space and in dielectric media, boundary-value methods, electric currents, conducting media, magnetostatics, macroscopic and microscopic magnetism, Faraday's law of induction. Prereq: COI. 3 u.

**203.2**[a,b] **Foundations of Electromagnetism II.** Maxwell's equations, covariant electrodynamics, motion in static electromagnetic fields, the Lienard-Wiechert potential, radiating systems, propagation of electromagnetic waves, wave guides and cavity resonators, classical electron theory. Prereq: Physics 203.1. 3 u.

**204.1**[a,b] **Foundations of Modern Physics I.** Fundamentals of modern physics with emphasis on atomic physics. Prereq: COI. 4 u.

**204.2**[a,b] **Foundations of Modern Physics II.** Fundamentals of modern physics covering lasers, x-rays, solids, nuclei, and particles. Prereq: Physics 204.1. 3 u.

[a] *This is part of a two-semester course*

[b] *Cannot be credited towards the MS (Physics) degree*

**204.5**[a,b] **Foundations of Quantum Mechanics I.** The uncertainty principle, the Schroedinger equation, one-dimensional systems, motion in central field, the postulates and mathematical formalism of quantum mechanics. Prereq: Physics 202.2, 204.1. 3 u.

**204.6**[a,b] **Foundations of Quantum Physics II.** Spin, time-independent and time-dependent perturbations, scattering, canonical quantization, identical particle systems, introduction to path integrals. Prereq: Physics 204.5. 3 u.

**205**[b] **Foundations of Statistical Physics.** Basic concepts and applications of classical statistical mechanics; quantum statistical mechanics of ideal gases. Prereq: Physics 202.1 3 u.

**206.5**[b] **Foundations of Optics.** Optics of planar surfaces, interference, and diffraction, phenomena, Fourier optics, image formation coherence, polarization. Prereq: Physics 203.2. 3 u.

**206.6**[b] **Physics of Lasers.** The theory of light matter interaction as applied to lasers, basic elements of lasers, general properties and applications of lasers. Prereq: Physics 204.1. 3 u.

**206.7**[b] **Physics of Condensed Matter.** Fundamentals of condensed matter physics. Prereq: Physics 204.2/204.6. 3 u.

**206.8**[b] **Physics of Nuclei and Particles.** Fundamentals of nuclear and particle physics. Prereq: Physics 204.6. 3 u.

**207**[b] **Seminar in Modern Physics.** Special topics of current interest in physics. Prereq: GS. 1 u.

**208**[b] **Foundations of Physical Electronics.** Fundamentals of electronics. Prereq: Physics 204.1. 6 h. (3 lec, 3 lab) 4 u.

**209.1**[a,b] **Foundations of Experimental Physics I.** Experiments in modern physics for college physics teachers. Prereq: Physics 208. 10 h. (1 lec, 6 lab, 3 shopwork) 4 u.

**209.2**[a,b] **Foundations of Experimental Physics II.** Selected advanced experiments in modern physics for college physics teachers. Prereq: Physics 209.1. 7 h. (1 lec, 6 lab) 3 u.

**210.1**[b] **Physics Teaching Practicum I.** Supervised practicum in conducting laboratory classes and/or discussion sessions in introductory college physics. Prereq: EDSC 278/equiv. (satisfactory-or-unsatisfactory basis). 2 u.

**210.2**[b] **Physics Teaching Practicum II.** Supervised practicum in conducting a lecture class in introductory college physics. Prereq: COI. (satisfactory-or-unsatisfactory basis). 3 u.

**211** **Mathematical Methods of Physics I.** Selected advanced methods in partial differential equations and integral equations such as Hilbert-space methods, Green-function methods, approximation methods, variational methods, and optimization methods. Prereq: Physics 113/equiv. 3 u.

**212** **Mathematical Methods of Physics II.** Selected topics in non-linear problems such as stability theory; bifurcation theory; asymptotic properties; perturbation methods; numerical methods; soliton theory and its applications. Prereq: Physics 113/equiv. 3 u.

**215** **Computational Methods of Physics.** Numerical methods; introduction to linear and dynamic programming; principles of simulation and modeling; computer languages for numerical solutions and algebraic manipulations. Prereq: App Physics 155/equiv. 3 u.

**221**[a] **Classical Dynamics I.** Introduction to dynamical systems, Hamiltonian dynamics, variational principles, canonical transformations, Hamilton-Jacobi theory, classical perturbation theory, advanced linear dynamics, classical field theory. Prereq: Physics 113, 122/equivs. 3 u.

**222**[a] **Classical Dynamics II.** Methods of nonlinear dynamics, chaotic dynamical systems, strange attractors, routes to chaos, solitary waves and solitons, the method of inverse scattering, kinks and vortices. Prereq: Physics 221. 3 u.

**225**[a] **General Relativity I.** Manifolds, modern differential geometry and tensor analysis; basic principles of general relativity; Einstein's field equations and their mathematical properties; exact solutions; linearized theory; variational principles and conservation laws; equations of motion; gravitational waves; experimental tests. Prereq: COI. 3 u.

**226**[a] **General Relativity II.** Spinor analysis; tetrad calculus; the spin-coefficient formulation of general relativity; asymptotic properties of space-time; conformal treatment of infinity; relativistic stars; gravitational collapse and black holes; space-time singularities; relativistic cosmology; and other selected topics. Prereq: Physics 225. 3 u.

**231**[a] **Classical Electrodynamics I.** The microscopic and macroscopic Maxwell equations; electrostatics in vacuum and in dielectrics; stationary currents and magnetostatics; conservation theorems for the electromagnetic field; plane electromagnetic waves; wave guides and resonant cavities. Prereq: Physics 113, 132/equivs. 3 u.

**232**[a] **Classical Electrodynamics II.** Electromagnetic multipole radiation; principles of special relativity; covariant formulation of electrodynamics; radiation from moving charges; bremsstrahlung; relativistic dynamics of charges and fields; classical electron theory; magnetohydrodynamics. Prereq: Physics 231. 3 u.

[a] *This is part of a two-semester course*

[b] *Cannot be credited towards the MS (Physics) degree*

**235[a] Plasma Physics I.** Dynamics of charged particles in electromagnetic fields; orbit theory; wave propagation in cold plasmas; magnetohydrodynamics; hydromagnetic oscillations and stability. Prereq: Physics 135/COI. 3 u.

**236[a] Plasma Physics II.** Plasma kinetic theory; statistical mechanics of charged particle systems. The BBGKY kinetic theory; the Vlasov equation; plasma oscillations, micro instabilities in some thermo-nuclear devices. Prereq: Physics 152, 235/COI. 3 u.

**241[a] Quantum Mechanics I.** Linear vector spaces and representation theory; general formulations; simple quantum mechanical systems; quantum dynamics; path integral methods. Prereq: Physics 142/ equiv. 3 u.

**242[a] Quantum Mechanics II.** Symmetries; stationary-state perturbation theory; time-dependent perturbation theory; collision theory. Prereq: Physics 241. 3 u.

**243 Quantum Mechanics III.** Quantum mechanics and group theory including such topics as group representations; the symmetric, permutation, crystallographic, and other finite groups along with their physical applications; the rotation group; introduction to unitary symmetry; Clebsch-Gordan, Wigner, and Racah algebras. Prereq: Physics 242. 3 u.

**245[a] Advanced Quantum Mechanics I.** Formal scattering theory; relativistic quantum mechanics; Feynman calculational techniques and Feynman graphs. Prereq: Physics 242. 3 u.

**246[a] Advanced Quantum Mechanics II.** Quantum theory of many-body systems using the methods of second quantization, Feynman graphs, Green functions, and other techniques. Prereq: Physics 245. 3 u.

**251[a] Statistical Mechanics I.** Thermodynamics of phase transitions; the Ginzburg-Landau theory; critical exponents; review of probability theory; master equation; the Fokker-Planck equation; random walk and the diffusion equation; probability density and Liouville's equation; ergodic theory; mixing flow; equilibrium statistical mechanics; equilibrium, fluctuations and critical exponents. Prereq: Physics 151/ equiv. 3 u.

**252[a] Statistical Mechanics II.** Elementary transport theory; Onsager's relations; Wiener-Khinchin theorem; fluctuation-dissipation theorem; linear response theory; response theory; thermodynamic stability criteria far from equilibrium; examples of nonequilibrium phase transitions. Prereq: Physics 251. 3 u.

**255[a] Atomic and Molecular Physics I.** Quantum-mechanical treatment of the structure and interactions of atoms and molecules: complex atomic spectra; Hartree-Fock-Slater methods; vector coupling; multiplet theory and Racah methods; transition probabilities and selection rules; molecular rotations and vibrations; group-theoretic methods in molecular physics. Prereq: Physics 242. 3 u.

**256[a] Atomic and Molecular Physics II.** Topics to be selected from rotational, vibrational, and electronic spectra of molecules; molecular orbitals; techniques of nuclear-magnetic resonance, microwave, electron-spin-resonance, infrared, Raman, optical and ultraviolet spectroscopy; applications to stellar spectra; introduction to the theory of atomic collisions. Prereq: Physics 255 (Continuation of Physics 255). 3 u.

**261[a] Laser Physics I.** Einstein's theory of light-matter interaction; rate equation; density matrix formalism of quantum mechanics; Maxwell-Schroedinger equations, Maxwell-Bloch equations; steady state behavior and instabilities of single-mode lasers; optical bistability; multimode laser operation and multimode instabilities; coherent pulse propagation. Prereq: Physics 161, 242/equivs. 3 u.

**262[a] Laser Physics II.** Quantum theory of radiation; coherent state of radiation; P-representation; squeezed states; quantum Fokker-Planck equation; quantum theory of the laser; photon and photoelectron statistics; quantum mechanical coherence; Langevin's theory of brownian motion; Langevin's theory of the laser. Physics 261. 3 u.

**265[a] Modern Optics I.** Foundations of geometrical optics; geometrical theory of imaging; geometrical theory of aberrations; theory of interference and interferometers; theory of diffraction; diffraction theory of aberrations. Prereq: Physics 165, 232/equivs. 3 u.

**266[a] Modern Optics II.** Theory of electromagnetic propagation in anisotropic media; Jones calculus as applied to birefringent systems; electromagnetic propagation in periodic media; electro-optics; parametric amplification and oscillation; Raman scattering; Brillouin scattering; phase conjugate optics; introduction to integrated optics. Prereq: Physics 265. 3 u.

**271[a] Solid State Physics I.** Fundamental principles of the physics of solids. Topics include periodic structure, lattice waves, electron states, static properties of solids, electron-electron interaction, dynamics of electrons in solids. Prereq: Physics 170, 242/equivs. 3 u.

**272[a] Solid State Physics II.** (Continuation of Physics 271).Transport and optical properties of solids, Fermi surface, magnetism, superconductivity, amorphous and disordered systems. Prereq: Physics 271. 3 u.

**275[a] Low-Temperature Physics I.** Properties of superconductors; the London, Ginzburg-Landau and BCS theories of superconductivity; the Josephson effect; and other topics in superconductivity. Prereq: Physics 170, 242/equivs. 3 u.

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[a] *This is part of a two-semester course*

**276[a] Low-Temperature Physics II.** Properties of liquid helium; the Landau, Feynman, and Bogolyubov theories of superfluidity; rotating helium; vortices; Fermi liquid; and other topics in superfluidity. Prereq:Physics 170, 242/equivs. 3 u.

**281[a] Nuclear Physics I.** Nuclear structure: self-consistent fields; shell model; single-particle excitations and vibrations, linearization methods; theory of deformed nuclei; pairing in nuclei; quasi-particles. Prereq: Physics 180, 242/equivs. 3 u.

**282[a] Nuclear Physics II.** Nuclear reactions: optical model; compound nuclear reactions; direct reactions; coupled-channel methods; other reaction theories. Prereq: Physics 281. 3 u.

**285[a] Elementary Particle Physics I.** Space-time properties of particles; classification of particles and their symmetries; properties of particles and their interactions. Prereq: Physics 180, 242/equivs. 3 u.

**286[a] Elementary Particle Physics II.** (Continuation of Physics 285). Selected topics in strong and weak interactions; current-algebras; dispersion theory; gauge theories; and S-matrix theory. Prereq: Physics 285. 3 u.

**290 Graduate Colloquium.** Prereq: GS. 1 u.

**291 Experimental Methods of Quantum Electronics and Optics.** Advanced laboratory techniques and instrumentation of quantum electronics and modern optics. Prereq: Physics 192/equiv. 7 h. (1 lec, 6 lab) 3 u.

**292 Experimental Methods of Condensed Matter Physics.** Advanced laboratory techniques and instrumentation of solid state physics and low-temperature physics. Prereq: Physics 192/equiv. 7 h. (1 lec, 6 lab) 3 u.

**293 Experimental Methods of Atomic and Molecular Physics.** Advanced laboratory techniques and instrumentation of atomic and molecular physics. Prereq: Physics 192/equiv. 7 h. (1 lec, 6 lab) 3 u.

**294 Experimental Methods of Nuclear Physics.** Advanced laboratory techniques and instrumentation of nuclear physics. Prereq: Physics 192/equiv. 7 h. (1 lec, 6 lab) 3 u.

**295 Experimental Methods of Plasma Physics.** Advanced laboratory techniques and instrumentation of plasma physics. Prereq: Physics 192/equiv. 7 h. (1 lec, 6 lab) 3 u.

**296 Graduate Seminar.** Prereq: GS. 1 u.

**299 Independent Master's Study.** Prereq: COA. (satisfactory-or-unsatisfactory basis). 3 u.

**300 MS Thesis.** Prereq: Completion of all course requirements. 6 u.

**301 Special Topics in Experimental Physics.** Advanced laboratory techniques and instrumentation in a specialized area of experimental physics that is not covered in the other courses. Prereq: COI. 1-3 u.

**305 Special Topics in Theoretical Physics.** Advanced topics in a specialized area of theoretical physics that is not covered in the other courses. Prereq: COI. 1-3 u .

**311 Advanced Mathematical Physics I.** Structure and representation theory of various Lie groups. Prereq: Physics 243. 3 u.

**312 Advanced Mathematical Physics II.** Selected advanced topics in topology, differential geometry, and related areas of mathematics that are important in contemporary theoretical physics. Prereq: COI. 3 u.

**313 Advanced Mathematical Physics III.** Selected advanced topics in functional analysis, operator algebras, and related areas of mathematics that are important in contemporary theoretical physics. Prereq: COI. 3 u.

**325 Advanced Topics in Gravitation I.** Selected advanced topics of current interest in general relativity and/or alternative classical theories of gravitation. Prereq: Physics 226. 3 u.

**326 Advanced Topics in Gravitation II.** Selected advanced topics related to the quantization of the gravitational field and/or its unification with other fields. Prereq: Physics 226. 3 u.

**335 Advanced Plasma Physics.** Selected advanced topics of current interest in plasma physics. Prereq: Physics 236. 3 u.

**341 Quantum Field Theory I.** Lagrangian field theory; field quantization; Feynman path integral in field theory; renormalization; dimensional regularization and its application to lambda phi$^4$ theory. Prereq: Physics 245. 3 u.

**342 Quantum Field Theory II.** Path integral formulation of gauge theories; perturbative evaluation of gauge theories; some applications to the theory of elementary particles; current problems. Prereq: Physics 341. 3 u.

**351 Advanced Statistical Mechanics.** Selected advanced topics of current interest in statistical mechanics. Prereq: Physics 252. 3 u.

**355 Advanced Atomic and Molecular Physics.** Selected advanced topics of current interest in atomic and molecular physics. Prereq: Physics 256. 3 u.

**361 Advanced Quantum Electronics I.** Selected advanced topics in laser physics such as advanced laser systems; optical detectors and modulators; optical fibers and optical communication; optoelectronic devices; integrated optics. Prereq: Physics 261. 3 u.

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[a] *This is part of a two-semester course*

**362** **Advanced Quantum Electronics II.** Selected advanced topics of current interest in non-linear optics and quantum optics. Prereq: Physics 262. 3 u.

**371** **Advanced Solid State Physics I.** Selected advanced topics in solid state physics with focus on semiconductors, metals, surfaces and interfaces, thin films, and amorphous materials. Prereq: Physics 272. 3 u.

**372** **Advanced Solid State Physics II.** Selected advanced topics in solid state physics with focus on dielectric materials, magnetic materials, phase transitions, and low-dimensional systems. Prereq: Physics 272. 3 u.

**375** **Advanced Low-Temperature Physics.** Selected advanced topics of current interest in superconductivity and superfluidity. Prereq: Physics 275, 276. 3 u.

**381** **Advanced Nuclear Physics.** Selected advanced topics of current interest in nuclear physics. Prereq: Physics 282. 3 u.

**385** **Current Topics in Particle Theory I.** Current topics in the gauge theories of strong, weak, and electromagnetic interactions as well as the unification problem. Prereq: Physics 285, 311, 341. 3 u.

**386** **Current Topics in Particle Theory II.** Additional current topics in theoretical particle physics. Prereq: Physics 385. 3 u.

**399** **Independent Doctoral Study.** Prereq: COA. (satisfactory-or-unsatisfactory basis). 3 u.

**400** **PhD Dissertation.** Prereq: Completion of all course requirements and passing of the Candidacy Examination. 12 u.

## MATERIALS SCIENCE AND ENGINEERING PROGRAM[a]

### GRADUATE

#### Materials Science and Engineering (MSE)

**201[b]** **Fundamentals of Materials Science and Engineering.** Materials classification, properties and applications; principles of processing: raw materials for the Philippine industry. Prereq: COI. 3 u.

**211[b]** **Laboratory Module in Transmitted Light Microscopy.** Prereq: COI. 3 h. (lab) 1 u.

**212[b]** **Laboratory Module in Mineragraphy.** Prereq: COI. 3 h. (lab) 1 u.

**213[b]** **Laboratory Module in Crystallography.** Prereq: COI. 3 h. (lab) 1 u.

**214[b]** **Laboratory Module in Vacuum Technologies and Thin Film Deposition.** Prereq: COI. 3 h. (lab) 1 u.

**215[b]** **Laboratory Module in Electronic and Magnetic Measurements.** Prereq: COI. 3 h. (lab) 1 u.

**216[b]** **Laboratory Module in Ceramics Processing and Characterization.** Prereq: COI. 6 h. (lab) 2 u.

**225[b]** **X-Ray Crystallography and Spectrography.** X-ray methods for the characterization of crystal structure and determination of chemical composition. Prereq: COI. 3 u.

**231[b]** **Thermodynamics of Materials.** Theory of thermodynamics: applications to phase equilibria. Prereq: COI. 3 u.

**233[b]** **Kinetics of Materials.** Reaction rates, mechanisms, and transport phenomena in materials. Prereq: COI. 3 u.

**241[b]** **Physics of Solids.** Band theory of solids and lattice vibrations; electrical, magnetic and optical properties. Prereq: COI. 3 u.

**243** **Epitaxial Growth.** Processing and preparation of semiconducting materials & related compounds, microstructures, and devices with emphasis on the principles of epitaxial growth; in-situ analytical methods for the evaluation of growth fronts. Prereq: MSE 241. 3 u.

**243.1** **Epitaxial Growth Laboratory.** Prereq: MSE 243. 6 h. (lab) 2 u.

**245** **Semiconductor Characterization.** Advanced methods of evaluating semiconductor materials, mircostructures and devices including electronic analysis, spectroscopy, x-ray diffraction and surface analysis. Prereq: MSE 241. 3 u.

**245.1** **Semiconductor Characterization Laboratory.** Prereq: MSE 245. 6 h. (lab) 2 u.

**265** **Ceramic Materials.** Structure and properties: synthesis and processing of ceramics; high technology and engineering applications. Prereq: MSE 241. 3 u.

**266** **Polymer Materials.** Structure, properties, and synthesis of polymers; processing and conversion to plastics; applications and performance of polymers. Prereq: COI. 3 u.

**267** **Surface Science.** Surfaces and interfaces; thermodynamics and electrical aspects of surfaces and interfaces; adsorption; chemisorption; catalysis; colloidal systems; applications to processing and manufacturing. Prereq: MSE 231. 3 u.

**268** **Degradation of Materials.** Degradation of, and effects of the environment on, metals, polymers, ceramics and composites. Prereq: MSE 231. 3 u.

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[a] *Offered by the Institute of Chemistry, National Institute of Geological Sciences, and National Institute of Physics, College of Science and the Department of Metallurgical and Mining Engineering, College of Engineering.*

[b] *6 units of Laboratory Modules in MSE (i.e. MSE 211-219) are required.*

**271** **Physics of Liquid Crystals.** Study of anisotropic fluids: main types and properties; long and short order in nematics; principles of the main field (Maier-Sanpe) and the continuum theories, static and dynamic properties of nematics, cholesterics and smectics; applications of liquid crystals. Prereq: COI. 3 u.

**271.1** **Liquid Crystals Laboratory I.** Characterization of LCs: optical microscopy; refractometry; uv-vis-ir spectrophotometry; FTIR; differential scanning calorimetry. Prereq: MSE 271. 6 h. (lab) 2 u.

**271.2** **Liquid Crystals Laboratory II.** Synthesis of LCs; fabrication of polymer dispersed liquid crystals (PDLC) fabrication; characterization and applications in simple LC devices. Prereq: MSE 271.1. 6 h. (lab) 2 u.

**275** **Advanced Physics of Solids I.** Fundamental principles of the physics of solids: periodic structure, lattice waves, electron states; static properties of solids; electron-electron interaction; dynamics of electrons in solids. Prereq: MSE 241. 3 u.

**276** **Advanced Physics of Solids II.** Transport and optical properties of solids, Fermi surface, magnetism, superconductivity, amorphous and disordered systems. Prereq: MSE 275. 3 u.

**296** **Graduate Seminar.** Prereq: COI. 1 u.

**298** **Special Problems.** Prereq: COI. 3 u.

**300** **MS Thesis.** Prereq: Consent of Thesis Adviser. 6 u.

**400** **PhD Dissertation.** Prereq: Passing of the Candidacy Examination. 12 u