CURRICULUM

OF

MARINE SCIENCES

FOR

4-YEARS BS PROGRAMME

HIGHER EDUCATION COMMISSION
ISLAMABAD – PAKISTAN

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum of subject is described as a throbbing pulse of a nation. By viewing curriculum one can judge the stage of development and its pace of socio-economic development of a nation. With the advent of new technology, the world has turned into a global village. In view of tremendous research taking place world over new ideas and information pours in like of a stream of fresh water, making it imperative to update the curricula after regular intervals, for introducing latest development and innovation in the relevant field of knowledge.

In exercise of the powers conferred under Section 3 Sub-Section 2 (ii) of Act of Parliament No. X of 1976 titled **"Supervision of Curricula and Textbooks and Maintenance of Standard of Education"** the erstwhile University Grants Commission was designated as competent authority to develop review and revise curricula beyond Class-XII. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission under its Ordinance of 2002 Section 10 Sub-Section 1 (v).

In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis working in universities and R&D institutions of technically advanced countries are also invited to contribute and their views are incorporated where considered appropriate by the National Curriculum Revision Committee (NCRC).

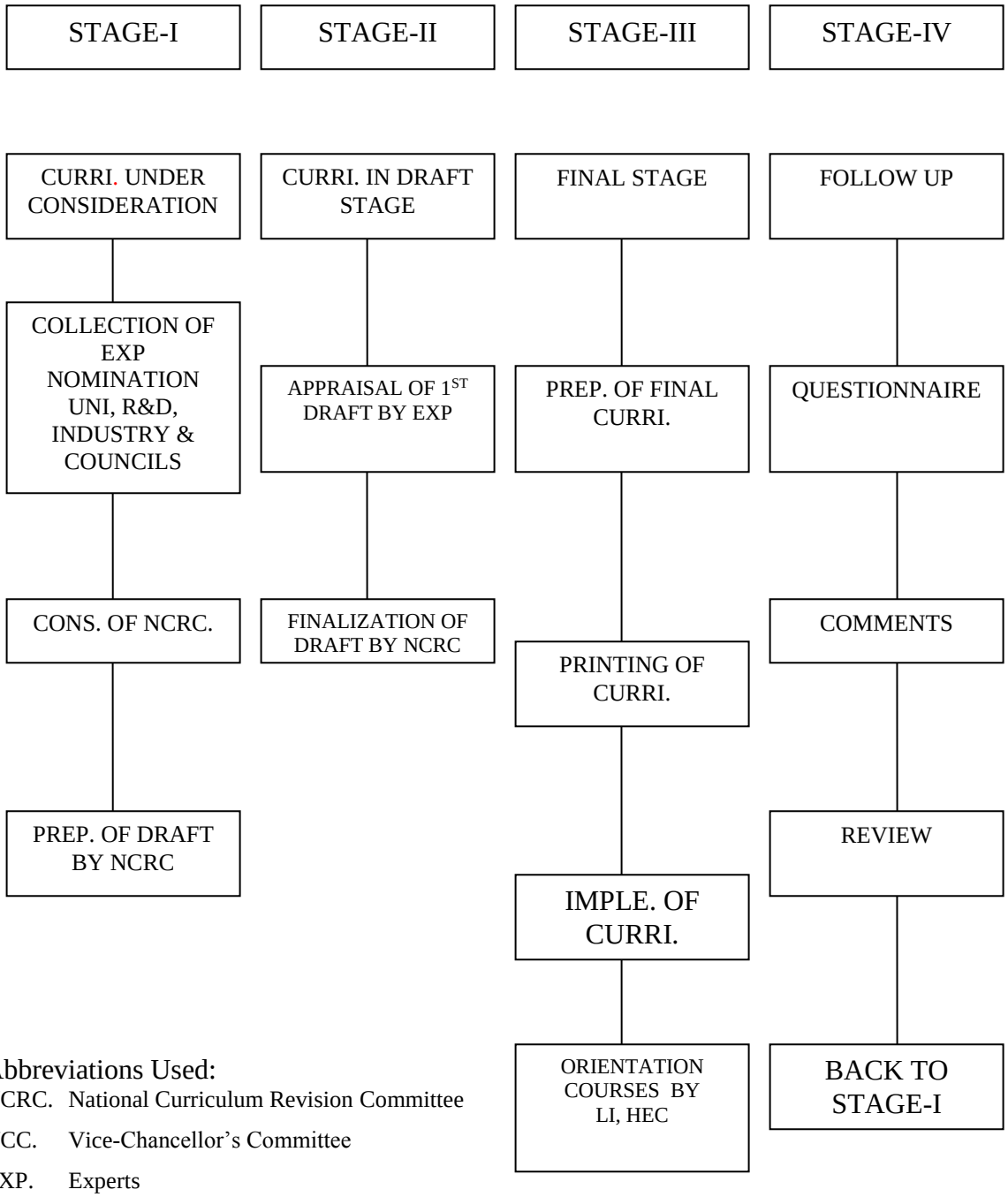
To bring international compatibility to qualifications held from Pakistani universities/DAIs for promotion of students mobility and job seekers around the globe, a Committee comprising of Conveners of the National Curriculum Revision Committee of HEC met in 2009 and developed a unified template for standardized 4-years/8-semesters BS degree programmes. This unified template was aimed to inculcate broader base of knowledge in the subjects like English, Sociology, Philosophy, Economics etc in addition to major discipline of study. The Bachelor (BS) degree course requires to be completed in 4-years/8-semesters, and shall require qualifying of 130-140 credit hours of which 77% of the curriculum will constitute discipline specific and remaining 23% will comprise compulsory and general courses.

In line with above, NCRC comprising senior university faculty and experts from various stakeholders and the respective accreditation councils has finalized the curriculum for BS 4-year in Marine Sciences. The same is being recommended for adoption by the universities/DAIs channelizing through relevant statutory bodies of the universities.

MUHAMMAD JAVED KHAN
Adviser Academics

June 2011

CURRICULUM DEVELOPMENT



Abbreviations Used:

NCRC. National Curriculum Revision Committee

VCC. Vice-Chancellor's Committee

EXP. Experts

COL. Colleges

UNI. Universities

PREP. Preparation

REC. Recommendations

LI Learning Innovation

R&D Research & Development Organization

HEC Higher Education Commission

INTRODUCTION

Final meeting of NCRC to finalize the draft curriculum of Marine Sciences, developed from October 4-6, 2010 was held on March 14-16, 2011 at HEC, Regional Centre, Karachi.

Following attended the meetings:

Dr. Pirzada Jamal Siddiqui **Convener**
Professor and Director
Centre of Excellence in Marine Biology
University of Karachi,
Karachi.

Dr. Athar Ali Khan **Member**
Professor
Department of Geology
University of Karachi
Karachi.

Dr. Tariq Masood Ali Khan **Member**
Professor
Institute of Environmental Sciences
University of Karachi
Karachi.

Dr. Rashida Qari, **Member**
Associate Professor and Director
Institute of Marine Sciences
University of Karachi
Karachi.

Dr. Shaukat Hayat Khan **Member**
Principal Scientific Officer
National Institute of Oceanography
Karachi.

Dr. Ghazala Siddiqui, **Member**
Associate Professor
Centre of Excellence in Marine Biology
University of Karachi
Karachi.

Dr. Asif Inam, **Member**
Senior Research Officer
National Institute of Oceanography
Karachi.

Dr. Nuzhat Afsar **Member**
Assistant Professor
Department of Marine Sciences
Lasbela University of Agriculture,
Water and Marine Sciences, Lasbela,
Balochistan.

Muhammad Asif Gondal **Member**
Assistant Professor,
Department of Marine Sciences
LasbelaUniversity of Agriculture,
Water and Marine Sciences, Lasbela,
Balochistan.

Dr. S. Shafiqur Rehman **Member**
Professor,
Department of Environmental Sciences
University of Peshawar,
Peshawar.

Dr. Naureen Aziz Qureshi, **Secretary**
Professor and Dean
Government College University Faisalabad (GCUF)
Faisalabad.

Meeting started with recitation from the Holy Quran.
Mr. Muhammad Javed Khan, Adviser Academics, HEC, Islamabad welcomed the participants and briefed them of the obligations of the Commission for review/revision and development of curricula at undergraduate and postgraduate level.

Dr. Muhammad Tahir Ali Shah, Deputy Director Curriculum, HEC, Islamabad explained the procedure for curriculum revision in the light of standard template for basic, social and applied sciences.

Prof. Dr. Pirzada Jamal Siddiqui, Director, Centre of Excellence in Marine Biology, University of Karachiand Prof. Dr. Naureen Aziz Qureshi**,** Dean, University of Veterinary & Animal Sciences, Lahore acted as Convener and Secretary, respectively, of the National Curriculum Revision Committee in Marine Science.

The committee consulted the existing curricula in Marine Sciences of local and technologically advanced countries universities and reviewed the courses, their contents and recommended books and suggested changes in the contents, text as well as reference books.

After detailed deliberation a unified draft curriculum for BS 4 year programme in Marine Science was developed.

Rationale of BS in Marine Science:

Placed in the northwestern part of Indian Subcontinent, Pakistan borders the Arabian Sea with a sizeable coastline running for approximately 990 Km in the east-west direction. Nearly 320 Km of this seashore falls in the province of Sindh whereas the rest of 670 Km constitute the Makran coast. The Exclusive Economic Zone, that stretches 200 nautical miles seaward from the coast, provides 240,000 Km^2 area of the Arabian Sea for exploitation of the renewable and non-renewable resources, on which coastal population of the Sindh and Balochistan provinces largely depend for their livelihood. Besides, a huge volume of raw materials, finished products and oil imported through the maritime trade as well as the exports of Pakistani products provides employment opportunities to thousands of families in the country.

Marine scientists work on the sustainable use, development and conservation of marine and coastal environment. Growing world population and depleting land based resources emphasizes the importance of oceans to produce food, energy and water from oceans to help sustain our basic needs. Advances in technology, will improve our ability to derive food, drinking water and energy sources from the oceans and use the same for waste disposal, and transportation. It will be up to us and our future generations to build upon our existing knowledge of oceans and their potential to help meet needs of the world and its inhabitants. Because of the growing concerns for the protection and prudent use of our natural resources, there is an increasing need for skilled personnel who can advise on, organize and control the development of marine resources and activities.

In view of the importance of Arabian Sea with respect to fishing, use of mangrove forest, its potential for offshore hydrocarbon exploration and import / export of goods through the ports of Karachi and Gawadar, makes it highly desirable that a fully devoted degree program is launched in Marine Sciences in order to cater for the need of appropriately trained and skilled manpower in this field. BS Marine Sciences is a branch of Earth Science that studies almost everything related with oceans, seas, their coasts and seabed. It covers a wide range of topics including ocean currents, waves and tides; marine organisms and ecosystem dynamics; fisheries; geophysical fluid dynamics; plate tectonics and geology of the sea floor including their minerals and hydrocarbon potential; and fluxes of various chemical substances and physical properties within the ocean and across its boundaries. These diverse topics relate to a multitude of disciplines like chemistry, physics, biology, geology, meteorology, and geography that oceanographers blend together to comprehend knowledge of the world oceans and processes within it. Marine science is a contemporary field of education having emerged as a

hybrid of traditional fields such as biology, chemistry and geology forming biogeochemistry.

The BS Marine Science programme will enroll students who have completed 12 years of schooling with traditional science courses as biology, chemistry, physics, and mathematics. It integrates science curricula so as to provide a thorough understanding of the related earth and life science education in the realm of oceans. The curriculum is designed to provide standard marine science education in Pakistan that can be divided into following branches and electives in each module:

- **Physical Oceanography**, or **marine physics**, studies the physical attributes of the oceans including temperature-salinity structure, mixing, waves, tides and currents, light and sound transmission, etc.
- **Chemical Oceanography** or **marine chemistry** is the study of chemistryof the ocean and its chemical interaction with the atmosphere;
- **Biological Oceanography** or **marine biology** is the study of plants, animals and microbes of the ocean and their ecological interaction with the habitat. The sustainable use of living resources may be provided through three separate modules with specific electives designed for fisheries, aquaculture and conservation biology.
- **Geological Oceanography** or **marine geology** studies the structure and morphology of the ocean floor, tectonic activity and volcanism associated with plate margins, continental margins, beaches and coastal areas, sediment transport and deposition regimes, and offshore mineral and hydrocarbon deposits etc.

The programme of BS in Marine Science is aimed at preparing graduates for a variety of interesting careers and opportunities. A marine scientist can be employed in federal, state and local government agencies to manage and monitor the use of resources, solve problems and conduct research. They can be employed by private industries such as seafood, fisheries, aquaculture, offshore energy resources, coastal hydraulics, ports and harbour development, satellite imagery, and ecological modeling, including environmental agencies and numerous non-government organizations.

STANDARDIZED TEMPLATE FOR 4-YEAR BS IN MARINE SCIENCES

Sr.	Categories	No. of courses Min – Max	Credit Hours Min – Max	Percentage
1.	Compulsory Requirement (No Choice)	9 – 9	25 – 25	19.23
2.	General Courses to be chosen from other departments	7 – 8	21 – 24	17.30
3.	Discipline Specific Foundation Courses	9 – 10	30 – 33	24.23
4.	Major Courses including research project / Internship	11 – 13	36 – 42	30.0
5.	Electives within the major	4 – 4	12 – 12	9.23
	Total	**40 – 44**	**124 – 136**	**100**

- Total numbers of Credit hours 124-136
- Duration 4 years
- Semester duration 16-18 weeks
- Semesters 8
- Course Load per Semester 15-18 Cr hr
- Number of courses per Semester 4-6 (not more than 3 lab / practical courses)

ELIGIBILITYFORADMISSIONIN4-YEARBS(HONS) PROGRAMME

Intermediate Science (or Equivalent) with minimum 2nd Division from the following groups:

1. Pre-Medical Group
2. Pre-Engineering Group
3. Other Groups(studied atleast two subjects from the following: Chemistry, Physics and Mathematics)

LAYOUT

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments		Discipline Specific Foundation Courses	
9 courses		7-8 courses		9-10 courses	
25 Credit hours		21-24 Cr. hours		30-33 Credit hours	
Subject	**Cr. hr**	**Subject**	**Cr hr**	**Subject**	**Cr hr**
1. ENGLISH I	3	General Chemistry	3	Introduction to Marine Sciences	**3**
2. ENGLISH II	3	General Biology	3	Marine Ecology and Ecosystem	**3**
3. ENGLISH III	3	General Physics	3	Marine Biochemistry	**3**
4. ENGLISH IV/ UNIV. OPTIONAL *	3	General Geology	3	Marine Microbiology	**3**
5. PAKISTAN STUDIES	2	Biostatistics	3	Marine Resources	**3**
6. ISLAMIC STUDIES / ETHICS	2	Introduction to sociology	3	Physical Oceanography	**4**
7. MATHEMATICS I	3	Basic Computer programming	3	Marine Biodiversity	**3**
8. STATISTICS **	3	Fundamentals of Economics	3	Application of Remote Sensing and GIS	**3**
9. INTRODUCTION TO COMPUTER	3			Introduction to Aquaculture	**3**
				Climatology and Climate change	**3**
	25		**24**		**31**

Major courses including research project/internship		Elective Courses within the major	
11-13 courses		4 courses	
36-42 Credit hours		12 Credit Hours	
Subject	**Cr. hr**	**Subject**	**Cr. hr**
Marine Geology	**3**		
Marine Chemistry	**3**	**Elective 1**	**3**
Coastal and Marine Sedimentology	**3**	**Elective 2**	**3**
Marine Geochemistry	**3**	**Elective 3**	**3**
Tectonics and Ocean Basin Evolution	**3**	**Elective 4**	**3**
Coastal Processes	**3**	**Elective 5**	**3**
Coastal Zone Management	**3**		
Marine Pollution and Control	**3**		
Marine Fisheries	**3**		
Functional Biology of Marine Organisms	**3**		
Oceanographic Instruments and Methods	**3**		
Geology of the Arabian Sea	**3**		
Field Project/ Internship	**3**		
	39		**15**

*** University has the option to recommend any other course in lieu of English IV**

**** University may recommend any other course in lieu of Mathematics II**

SCHEME OF STUDY FOR 4-YEARS BS IN MARINE SCIENCES

Note: **Students are required to select one module consisted of 5 courses each out of six modules proposed in the 8th semester. Mar. Sci. 607 is field based project required in the 8th semester.**

Semester/Year	Name of Subject	Credits
First Semester		
Eng 301	English-I	3
Pk.St. 301	Pakistan Studies	2
Math 301	Mathematics	3
Mar. Sc. 301	Introduction to Marine Science	3
Chem. 301	General Chemistry	3(2+1)
Bio. 301	General Biology	3(2+1)
		17
Second Semester		
Eng 302	English-II	3
Isl.St. 302	Islamic Studies / Ethics	2
Stat. 302	Statistics	3(2+1)
Geo. 302	General Geology	3(2+1)
Phy. 302	General Physics	3(2+1)
		14
Third Semester		
Eng-401	English-III	3
Comp. 401	Computer Applications	3(2+1)
Stat. 401	Biostatistics	3
Soc. 401	Introduction to Sociology	3
Mar.Sci. 401	Marine Ecology and Ecosystems	3(2+1)
		15
Fourth Semester		
Comp. 402	Basic Computer programming****	3(2+1)
Econ. 402	Fundamental of Economics	3
Mar. Sci. 403	Marine Biochemistry	3(2+1)
Mar. Sci. 404	Marine Microbiology	3(2+1)
Mar. Sci. 405	Marine Resources	3(2+1)
		15

Fifth Semester		
Mar. Sci.501	Physical Oceanography	4(3+1)
Mar. Sci. 502	Marine Biodiversity	3(2+1)
Mar. Sci. 503	Application of Remote Sensing and GIS	3(2+1)
Mar. Sci. 504	Introduction to Aquaculture	3(2+1)
Mar. Sci. 505	Climatology and Climate Change	3
		16
Sixth Semester		
Mar. Sci.506	Marine Geology	3(2+1)
Mar. Sci.507	Marine Chemistry	3(2+1)
Mar. Sci.508	Coastal and Marine Sedimentology	3(2+1)
Mar. Sci.509	Marine Geochemistry	3(2+1)
Mar. Sci.510	Ocean Basin Evolution	3(2+1)
Mar. Sci.511	Coastal Processes	3(2+1)
		18
Seventh Semester		
Mar. Sci.601	Coastal Zone Management	3(2+1)
Mar. Sci.602	Marine Pollution and Control	3(2+1)
Mar. Sci.603	Marine Fisheries	3(2+1)
Mar. Sci.604	Functional Biology of Marine Organisms	3(2+1)
Mar. Sci.605	Oceanographic Instruments and Methods	3(2+1)
Mar. Sci.606	Geology of the Arabian Sea	3(2+1)
		18
Eight Semester		
607	Field Project / Internship	3
	ELECTIVE I	3
	ELECTIVE II	3
	ELECTIVE-III	3
	ELECTIVE-IV	3
	ELECTIVE-V	3
	TOTAL – 124-136	**18**

LIST OF GROUPS AND ELECTIVE COURSES

Groups	Elective Course	Credit Hour (CH)
Module 1 AQUACULTURE		
Mar. Sci.611	**Aquaculture Systems**	3(2+1)
Mar. Sci.612	**Hatchery operation and Management**	3(2+1)
Mar. Sci.613	**Aquaculture nutrition**	3(2+1)
Mar. Sci.614	**Aquaculture Environmental management**	3(2+1)
Mar. Sci.615	**Aquaculture Health Management**	**3**(2+1)
Module 2 MARINE FISHERIES		
Mar. Sci.621	**Ichthyology**	**3**(2+1)
Mar. Sci.622	**Seafood Handling, processing and Safety**	**3**(2+1)
Mar. Sci.623	**Fisheries Techniques and Methods**	**3**(2+1)
Mar. Sci.624	**Fisheries Resources and Management**	**3**(2+1)
Mar. Sci.625	**Fisheries Economics, Marketing and Management**	**3**(2+1)
Module-3 CONSERVATION BIOLOGY		
Mar. Sci.631	**Diversity of Life**	**3**(2+1)
Mar. Sci.632	**Chemistry of life**	**3**(2+1)
Mar. Sci.,633	**Biology and Behaviour of marine animals**	**3**(2+1)
Mar. Sci.634	**Cell and Evolutionary Biology**	**3**(2+1)
Mar. Sci.635	**Conservation Ecology**	**3**(2+1)
Module 4 CHEMICAL & ENVIRONMENTAL OCEANOGRAPHY		
Mar. Sci.641	**Marine and Estuarine Chemistry**	**3**(2+1)
Mar. Sci.642	**Marine Environmental Toxicology**	**3**(2+1)
Mar. Sci.,643	**Marine Biogeochemistry**	**3**(2+1)
Mar. Sci.644	**Marine Natural Product Chemistry**	**3**(2+1)
Mar. Sci.645	**Marine Environmental Impact Assessment**	**3**(2+1)

Module 5 MARINE GEOLOGY		
Mar. Sci.651	**Marine non-living resources**	**3**(2+1)
Mar. Sci.652	**Introduction to Exploration Geophysics**	**3**(2+1)
Mar. Sci.653	**Paleo-oceanography**	**3**(2+1)
Mar. Sci.654	**Quaternary Geology**	**3**(2+1)
Mar. Sci.655	**Sea level Changes and Coastal Zone**	**3**(2+1)
Module 6 PHYSICAL OCEANOGRAPHY		
Mar. Sci.661	**Natural Hazards and the Oceans**	**3**
Mar. Sci.662	**Oceanographic Instrumentation**	**3**(2+1)
Mar. Sci.663	**Air - Sea Interaction**	**3**
Mar. Sci.664	**Ocean Dynamics**	**3**
Mar. Sci.665	**Ocean Modeling**	**3**

DETAIL OF COURSES
FOR 4-YEAR BS IN MARINE SCIENCE

INTRODUCTION TO MARINE SCIENCES

Course code: Mar. Sci 301
Credit Hours: 3+0 (3)

Specific Objectives of Course:
To understand basics of Marine sciences, its biological geological, chemical and physical characteristics and interrelationship.

Course Outline:
A History of Marine Science, Basic Structure of the Earth, Plate Tectonicsand ocean basins, Basics of Ocean Chemistry, Basics of Ocean Physics, Climate System, Waves, Tides and Ocean currents, Life in the Oceans, Marine Ecology, Marine plants (seaweeds and mangroves), Plankton, benthos, Nectons, Food chains and food webs. Oceanic Resources, Marine Pollution.

RECOMMENDED BOOKS:

1. Oceanography, An introduction to the Marine Environment by Peter K. Weyl. New York, John Wiley & Sons, Incorporated, 1970 (ISBN:0-471-93744-4). pp. 535,
2. Oceanography: A view of the Earth by Grant Gross. (ISBN: 0132317885 / 0-13-231788-5) Prentice Hall, 1995.
3. Compendium on UN Law of the Sea.
4. Oceanography, An Introduction to the Planet Oceanus by Paul R. Piney 1992.
5. The Oceans; Their Physics, Chemistry, and General biology. Sverdrup, H.U., Johnson, M.W., and Fleming, R.H., 1942. Prentice-Hall, New York, pp.1087.

GENERAL CHEMISTRY

Course code: Chem. 301
Credit Hours: 3 (2+1)

Objectives:
The main objective of this course is to provide a basic knowledge and understanding of chemistry and principles of chemical reactions. The course not only provides excellent practice in basic chemistry, but also allows the rigorous development of experimental schemes and analytical methods, relying on physical chemistry and analytical reasoning.

Course Outlines:
Chemical Bonding, Periodic tables. Ionic, covalent, coordinate covalent bond. Radioactivity and its environmental hazards. General chemistry of functional

groups of organic compounds (alcohols, carbonyls, esters, carboxylic acids, amines). Aromatic compounds, ions, radicals. Photochemical reactions. Solution chemistry. Surface chemistry. Colloids chemistry. Thermodynamics and chemical kinetics.

Lab Work:

Preparation of molar, molal, normal solutions/buffers. Osmosis and Dialysis. Paper Chromatography (one and two dimensional), Thin layer chromatography, Column chromatography. Measurement of pH, EC and TDS. Use of titrimetric and gravimetric analysis. Use of spectrophotometric techniques.

RECOMMENDED BOOKS:

1. Principles of Environmental Chemistry, Girard, J.E., 1st Ed. Jones and Barlett, USA, 2005.
2. An Introduction to Environmental Chemistry, Andrews, J.E., Brimblecombe, P., Jickells, T.D., Liss, P.S. and Reid, B.J., 2nd Edition. Blackwell Science, UK, 2004.
3. Fundamentals of Analytical Chemistry, Skoog, D.A., West, D.M. and Holler, F.J., 8th Edition. Thomson and Brooks, Canada, 2004.
4. Understanding Environmental Pollution, Hill, M.K., 2nd Edition. Cambridge University Press, UK, 2004.
5. Qualitative Chemical Analysis, Harris, D.C., 6th Edition. W.H. Freeman and Company, USA, 2003.

GENERAL BIOLOGY

Course code: Biol. 301
Credit Hours: 3 (2+1)

Objectives:

The course provides wide range coverage to principles of life. Particular emphasis is on chemical basis of life and polymerization in carbohydrates, lipids, proteins and nucleic acids. The course will impart knowledge about enzymes and phenomenon of hereditary transformation in living organisms.

Course Outlines:

Introduction: Definition and concept of life, chemical basis of life. Structure and the basis of function, chemical diversity, functional groups in functional diversity: Molecules of life and Polymerization; carbohydrates, lipids, proteins, phospholipids in membrane systems, polypeptides in protein diversity, enzymes as molecular tools in chemical transformations. Nucleic acids; the molecules of genetic information and replication. Origin of life: chemical evolution, origin of metabolism. protobionts, Origin of prokaryotic and eukaryotic cells. Introduction to cell biology, overview of structure and function of cell organelles. Cell division.

Lab Work:
Identification of the chemical nature of different animal and plant materials. Cytochemical demonstration of DNA and RNA in Avian blood and Protozoa. Biochemical tests for carbohydrates and proteins, lipids. Plasmolysis and deplasmolysis in blood cells. Protein digestion by enzyme pepsin. Gram staining of bacteria and study of fungus. Study of mitosis in onion root tip. Study of meiosis in Grasshopper testis.

RECOMMENDED BOOKS:

1. Biology' Campbell, N. A. 8th Ed. The Benjamin / Cummings Publishing Company Inc. New York. USA, 2008.
2. Holes's Human Anatomy and Physiology, Shier, D., Bulter, J. and Lewis, R. McGraw- Hill International Edition. USA; 2007.
3. Molecular Biology through Questions, Self Assessment and Review, Crossley, M. and Whitelaw, E. McGraw –Hill Book Company Pvt. Ltd., Australia , 1996.
4. Cells, Lewis, B., Cassimeris, L., Lingappa, V. R., Plopper, G. Jones and Bartlett Publishers. Canada, 2007.
5. Biology: a Human Emphasis, Starr, C. 5th Edition. Wadsworth Group. USA, 2003.

GENERAL GEOLOGY

Course code: Geol-302
Credit Hours: 3 (2+1)

Prerequisites: None

Specific Objectives of Course:
This course is designed to acquire the knowledge about the basic concepts of Geology. This will help the students to get knowledge about various types of rocks and minerals and the processes of their formation.

Course Outline:
Introduction and scope of geology, its importance and relationship with other sciences. Earth as a member of the solar system; its origin, age, composition and internal structure. Introduction to rocks and minerals. Introduction to plate tectonics, mountain building processes earthquake and volcanoes. Primary sedimentary, igneous and metamorphic structures. Introduction of folds, faults, joints, cleavage, foliation, lineation and unconformities. Weathering and erosion. Isostasy. Geological Time Scale.

Lab Outline:
Study of relief features with the help of models and topographic maps. Identification of rocks and minerals.

RECOMMENDED BOOKS:

1. Principles of Physical Geology by Holmes, A., 1978, Nelson.
2. Foundation of Structural Geology by Park, R.G., 1983, Blackie.

3. Elementary Exercises upon Geological Maps by Platt, J. I., 1961, Thomas Murby & Co.
4. An Introduction of Geological Structures and Maps by Bennison, G.M., 1997, Edward Arnold.
5. Physical Geology by Plummer, McGeay & Carlson, 2005.
6. Lab Manual for Physical Geology by Jones, Norris. W., Johnes, Charles E., 2005, McGraw-Hill.
7. How Does Earth Work: Physical Geology and Process of Science. Smith, G. and Pun, A.,2006, Prentice Hall.
8. The Mapping of Geological Structures by McClay, K. R.,1987,Open University Press.

Journals/Periodicals

- Geology
- Geological Society of America
- Nature
- Inside Earth
- Oceanus Magazine

World Wide Web:

- http://www.ngdc.noaa.gov/
- http://www.geolsoc.org.uk/
- http://www.gsp.gov.pk/

BASIC COMPUTER PROGRAMMING

Course code: Comp. 402
Credit Hours: 3(2+1)

Specific Objectives of Course:

This course intends to provide an overview of development in computer technology, communication technology, and application software.

Course Outline:

System software: component of system software, The operating system, Common microcomputer, operating systems, Utility programs, The network computer processor, Microchips, The CPU and main memory, How data and programs are represented in computer, The microcomputer system unit storage fundamentals, Diskettes, Hard disk, Flash memory, Magnetic tape, Online secondary storage and decompression, The future of secondary storage.

Lab Outline:

Application software tools, MS paint, MS Word, MS Excel, MS Power point.

RECOMMENDED BOOKS:

1. Carl Erik Froberg; Introduction to Numerical Analysis, (2nd Ed.), Addison Wesley Publishing Co., 1969. pp. 433.
2. Shan S. Kuo; Computer Application of Numerical Methods,

National Book Foundation, Islamabad. 1972. pp. 415.
3. William S. Dorn and Daniel D. McCracken; Numerical Methods with Fortran IV Case Studies. 1987 ISBN: 0898749824, pp. 462.
4. Don Yates (1988); Basic Systems Analysis, ELBS, USA.
5. Race, J. (1988); A Professional Guide to Systems Analysis, McGraw Hill Book Company.

MARINE ECOLOGY AND ECOSYSTEMS

Course code: Mar. Sci. 401
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:
To understand the basic functional definition of ecology and ecosystem.

Course Outline:
Abiotic and biotic components of an ecosystem, Habitat and zonation. Primary Production, factor affecting primary productivity. Consumer in marine environment: Dynamics of populations, competition, Feeding and response, Food selection, Processing of conserved energy. Structure and dynamics: Marine communities, Trophic structure, Taxonomic structure, social structure, colonization and succession. Function of marine ecosystem: Nutrient cycling, Seasonal changes, Long-term and large scale changes.

Lab. Outline: Field reports, case studies of coastal ecosystems.

RECOMMENDED BOOKS:
1. Marine Ecology: Concepts and Applications**,** 2010 Martin R. Speight, P. A. Henderson, Willey and Blackwell.
2. Marine ecology, 2007, Sean D. Connell, Bronwyn M. Gillanders, Oxford University Press.
3. Elements of marine ecology, 1998, Ronald Victor Tait, Frances Dipper, Butterworth and Heinemann.
4. An introduction to marine ecology, 1999, R. S. K. Barnes, Richard Stephen Kent Barnes, R. N. Hughes**,** Wiley-Blackwell.
5. Intertidal Ecology, 1999 David G. Raffaelli, Stephen J. Hawkins, Springer Verlag.
6. Marine ecological processes 1995, Ivan Valiela, Springer.
7. Fundamentals of Aquatic Ecology, 1991, Richard Stephen Kent Barnes, Kenneth Henry Mann, Willey and Blackwell.

Journals/Periodicals
- The Biological Bulletin.
- Journal of Experimental Marine Biology and Ecology.
- Journal of marine Biological Association UK.
- Marine Ecology.
- Marine Ecology Progress Series.

- Marine Biology.

MARINE BIOCHEMISTRY

Course code: Mar. Sci. 403
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

1. Characteristics and functions of major building blocks of marine organism
2. General understandings of simple biochemical processes in an organism
3. Learning of different metabolic pathways in a marine organism

Course Outline:

Water chemistry: ionizations of water, buffers, pH, Diffusion and osmosis, Metabolism, Structure, function and metabolism of protein, Carbohydrates, and Lipids, Nucleic acids, Vitamins, Enzymes and hormones. Electron transport chain.. Energy source, carbon and nitrogen input and assimilation (Photosynthesis, Nitrogen fixation, Respiration).

Lab. Outline:

pH of buffer solutions. Preparation of buffers i.e. citrate buffer and Phosphates buffers and carbonate buffers. Methods for estimation of Proteins, Carbohydrates, lipids and Vitamins. Techniques: Spectro-photometeric techniques, Chromatographic techniques, Electrophoresis etc.

RECOMMENDED BOOKS:

1. Zubay, G. (1989); Biochemistry second Ed., Maxwell, Macmillan, N.V.
2. Bohinski, C.R. (1982); Modern Concepts in biochemistry, Fourth ed., Allyn and bocon, Inc. Boston.
3. Voet, D., Voet, G.J. (1995); Biochemistry, Wiley and Sons, Inc., N. V.
4. Stryer, L. (1995); Biochemistry, Forth Ed., WIC freeman and Company, N.V. 5. Ramn, D.J. (1989); Biochemistry, Noil Patterson Publishers, Burlinson.
5. The biochemical ecology of marine fishes G. E. Shulman,R. Malcolm Love – 1999.
6. Themarine biochemistryof molybdenumC.B. Tuit – 2003.

MARINE MICROBIOLOGY

Course code: Mar. Sci. 404
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

Students will learn about the microbial world in seas and oceans, their role in the environment, importance in the marine food web.

Course Outline:

Introduction to marine microbiology: microbial environment, biological organization and evolution, importance of microbes and their sizes, chemical & physical factors influencing microbial distribution and processes, marine microbial habitat; Methods in microbiology, Cell structure and function, physiological processes; Eukaryotic microbes (nanoplanktonic flagellates, dinoflagellates, ciliates, diatom, cocolithophorids, radiolarians, foraminifera, fungi), Prokaryotic microbes (virus, bacteria and cyanobacteria, marine *Archaea*), Role of microbes in oceanic processes (primary productivity, carbon and nitrogen cycling), marine microbial loop, Eutrophication, Symbiotic Association, Harmful microbes (pathogens and toxin producing) in relation to human and marine organisms (fish and invertebrates), Marine microbes and human society.

RECOMMENDED BOOKS:

1. Marine microbiology: ecology and applications, Colin B. Munn – 2004.
2. Marine microbiology John H. Paul – 2001.
3. Marine microbiology Brian Austin – 1988.
4. Marine microbiology Carol D. Litchfield – 1976.
5. Alien ocean: anthropological voyages in microbial seas. Stefan Helmreich – 2009.
6. Marine microbiology Abhijit, Mitra, Kakoli Banerjee – 2004.
7. The living ocean: marine microbiology. E. J. Ferguson Wood – 1975.

MARINE RESOURCES

Course code: Mar. Sci. 405
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

1. Broadening the scope of harvesting of marine resources
2. Technological advancement in developing conventional and non-conventional marine products
3. Sustainable utilization and development of marine resources

Course Outline:

Identification of living and non-living resources on the coastal, seabed and offshore areas. Aggregates, sea salt. Gas hydrates, commercially important seabed minerals. Renewable energy from waves, tides, currents. Sustainable development of coastal and offshore resources. Non-Fish resources (sponges, crustacea, molluscan, echinoderms, turtles, mammals, seaweeds) Plankton fisheries and peral fisheries, exploration of local potential commercial species with reference to regional fisheries. Introduction to use of GIS as a tool for study of coastal resources.

Lab. Outline:

Identify coastal resources along the Pakistan Coast. Introduction of GIS techniques to develop and highlight coastal resources.

RECOMMENDED BOOKS:

1. Marine resources**:** property rights, economics and environmentMax Falque, Michael De Alessi, Henri Lamotte – 2002.
2. Livingmarine resources**:** their utilization and managementEdwin S. Iversen – 1996.
3. Large marine ecosystems of the Indian Ocean: assessment, sustainability and management. Kenneth Sherman,Ezekiel Okemwa,Micheni J. Ntiba– 1998.

PHYSICAL OCEANOGRAPHY

Course code: Mar. Sci. 501
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

This course is designed to introduce students to the important physical processes in the oceans in such a way that they will understand both the conceptual physical principles and at the larger scale how these fit into the earth as a system.

Course Outline:

Ocean dimentions, shape and bottom material, Physical Properties of Seawater, Chlorinity, salinity, thermal properties, density, pressure, optical properties, transmission of sound, formation of water masses, T-S diagram, Equation of state of seawater, General ocean circulation, dynamics of circulation, Ekman flow, Upwelling, convergence, Western and Eastern boundary currents, thermohaline circulation; Ocean Waves and Tides, Coastal Processes, Long shore currents, Rip currents, oceanography of Arabian sea, instruments and methods.

Lab. Outline:

Plotting and understanding basic Oceanographic parameters and sampling techniques, instruments and methods. Data handling and processing using dedicated software

RECOMMENDED BOOKS:

1. Descriptive Physical Oceanography, by G. L. Pickard and William J. Emery. 2002
2. Oceanography, An introduction to the Marine Environment by Peter K. Weyl. 1969
3. Oceanography: A view of the Earth by Grant Gross 1995.
4. Compendium on UN Law of the Sea.
5. Oceanography, An Introduction to the Planet Oceanus. 1992 by Paul R. Pinet.
6. The Oceans; Their Physics, Chemistry, and General biology. Sverdrup, H.U., Johnson, M.W., and Fleming, R.H., 1942. Prentice-Hall, New York, pp.1087

Journals/Periodicals:

- Journal of physical oceanography
- Physical oceanography
- Journal of deep sea research
- Continental shelf research
- Estuarine, coastal and shelf science

World Wide Web:

- www. ioc-unesco.org
- http://www.wmo.int

MARINE BIODIVERSITY

Course code: Mar. Sci. 502
Credit Hours: 3(2+1)
Prerequisites: None

Objective:

To understand the structure and function of marine biodiversity components from genes to habitats and develop skills to carry out impact assessment and conservation.

Course Outline:

The structure and functioning of Marine Biodiversity (from genes to habitats) and with Impact studies and its relationship with the basic oceanographic processes. Toolbox for investigating marine biodiversity for attempting data analysis: experimental design, modeling, taxonomy, Evolution, Invasive species, data and Information Management, Field observations and interpretation and Molecular methods; Molecular bar-coding of biodiversity, Conservation, Laws for conservation, Marine protected areas. Conservation and Restoration of marine

biodiversity and application of the above mentioned theories and methods in order to develop a sustainable use of the marine environment.

Lab. Outline: Laboratory work on major biological taxa, field trips on biodiversity in situ, computer labs for informatic tools. Design and present a specific marine conservation project report writing and discussions covering marine conservation issues, including informal student presentations on political, economic, historical, educational, and natural science issues related to conservation and analysis of marine biodiversity.

RECOMMENDED BOOKS:

1. Marine Biodiversity: Patterns and Processes, Rupert F. G. Ormond, John D. Gage, Martin V. Angel - 2005 - 472 pages
2. The Living Oceans, B. Thorne Miller, Island Press, USA
3. Marine Conservation Biology: a science of maintaining the Sea's Biodiversity, E. Norse and L. Crowder. 1999. Island Press, USA
4. Marine biodiversity: patterns and processes, assessment, threats, management and conservation. Henrique Queiroga. 2006 Springer.

APPLICATION OF REMOTE SENSING AND GIS

Course code: Mar. Sci. 503
Credit Hours: 3(2+1)
Prerequisites: None

Objective:

This course is designed to introduce principles, concepts and applications of Geographic Information Systems (GIS) and Remote Sensing (RS): a decision support tool for planners and managers of spatial information and to obtain information on the earth from decimeter level to km level locally and globally.

Course Contents:

Introduction to Geographical Information System, Data Types (Spatial / Aspatial), Data Models and Structures (Raster / Vector), Data Sources and Capturing Techniques, Displaying and Manipulating spatial information, Vector Data Preparation (Digitization and Spatial Data Editing), GPS Survey, Introduction to the concept of RS, Electromagnetic Spectrum, Atmospheric Interaction, Technology of Remote Sensing (Orbits, Satellites, Sensors and Platforms), Applications of Remote Sensing, Satellite Image Processing Cycle, Image Enhancement, Data Fusion and Mosaicking, Information Extraction (Classification and Vectorization).

Lab. Outline: Introduction to ArcGIS, Exploring GIS Dataset in ArcCatalog, Working on vector data in ArcGIS (Scanning, Digitization and Editing), Integrating GPS data in GIS Environment, Applications of GIS, ERDAS Imagine - Environment, Noise Corrections, Geometric Corrections, Radiometric Corrections.

RECOMMENDED BOOKS:

1. Matt Duckham, Michael F. Goodchild, Michael F. Worboys, (2003) Foundations of Geographic Information Science, Tylor & Francis, NewYork, USA.
2. Michael N. Demers (2002) Fundamentals of Geographic Information System, , John Wiley & Sons, Inc., Singapore.
3. Basanta Shrestha & Birendra Bajracharya (2000), GIS for Beginners, By ICIMOD, Kathmandu, Nepal.
4. Kang-tsung Chang (2002) Introduction to Geographic Information Systems, McGraw- Hill Company, New York, U.S.A.
5. W. G. Rees (2001) Physical Principles of Remote Sensing Cambridge University Press, United Kingdom. ISBN: 0521669480.
6. Robert A. Schowengerdt (January 15, 1997) Remote Sensing 2nd edition, Academic Press ISBN: 0126289816.
7. Thomas M. Lillesand & Ralph W. Kiefer (Year 2000) Remote Sensing and Image Interpretation John Wiley & Sons, Inc.
8. James B. Campbell (1996) Introduction to Remote Sensing, The Guilford Press, New York, USA.

INTRODUCTION TO AQUACULTURE

Mar. Sci. 504
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

To develop the basic learning and practical knowledge in the field of aquaculture.

Course Outline:

Carrying capacity modules, Finfish, shellfish culture systems (hatchery to grow-out), Pond, cage, raft and line culture system, Seaweed and micro algae culture, Water quality, Feed and feeding efficiency, fish health issues in aquaculture.

Lab. Outline:

Water quality assessment and management
Techniques of broodstock conditioning and spawning
Formulation and preparation of balanced aqua feed
Procurement and culture of live feeds
Feeding trials on fish, shrimp and bivalves
Estimation of feed conversion efficiency
Estimation of specific growth rate from data obtained

RECOMMENDED BOOKS:

1. Aquatic Engineering (Mike Walker).

2. Sustainable Aquaculture by J.E Bardach. 1997
3. Intensive Fish Farming by Jonathan Shepherd and Niall Bromage 1992.
4. Fish Hatchery Management by G Wedemeyer 2001.
5. Cage Aquaculture by M. Beveridge. 2004
6. FAO Manual on Hatchery Production of Seabass and Gilthead Seabream by Alessandro Moretti and Mario Pedini Fernandez-Criado 2005
7. Responsible Marine Aquaculture. Edited by Stickney and JP McVey, 2002.
8. Aquaculture: Principles and Practices. T.V.R. Pillay and M. N. Kutty, 2005.

Journals/Periodicals:

- Aquaculture
- Aquaculture Research
- Aquaculture Nutrition
- Aquaculture International
- Aquaculture Engineering.

CLIMATOLOGY AND CLIMATE CHANGE

Course code: Mar. Sci. 505
Credit Hours: 3
Prerequisites: None

Specific Objectives of Course:

Climate change is one of the most controversial issues of the 21st century. This introductory course presents Earth's climate system and explores the science and related issues of global climate change.

Course Outlines:

Fundamental principles of climatology; Earth-Sun relationship: earth's radiation balance, latitudinal and seasonal variation of insulation, temperature, humidity, wind and precipitation Indian climatology with special reference to seasonal distribution and variations of temperature, humidity, wind and precipitation; air masses notably monsoons' and jet streams, tropical cyclones, and cloud formation, classification of climates, Koppen's and Thornthwaite's schemes as applicable to India. Climatic zones of India. Hydrological cycle and water balance. Climate change; green house warming, stratospheric ozone depletion. Palaeoclimatology. Principal seasons of subcontinent, winter season; western disturbances, anticyclones and associated weather, fog, hail, thunderstorms, cold waves, subtropical westerly jet stream, pre-monsoon season; cyclonic storms, dust storm, heat waves, southwest monsoon season; onset and advance of monsoon; semi permanent components of monsoon, active and break cycle, monsoon depressions, rainfall and its variability, drought, aridity, Post-monsoon season ; north-east monsoon, cyclonic storms in Indian seas.

RECOMMENDED BOOKS:

1. Physical Climatology by William D. Sellers. 1969
2. Introduction to Climates by Glenn T. Trewartha. McGraw-Hill 2002.
3. Climatology by Haurwitz & Austin. McGraw-Hill Education 1944. 410 pp.
4. World Climatology: An environmental approach by Lockwood. 1974, 330pp
5. The Weather Makers: Our Changing Climate and what it means for Life on Earth by Tim Flannery. 2006.
6. Atmosphere, Weather and Climate by Barry. 2003. 472 pages.

Journals/Periodicals:

- Climate Change
- Climate Change Journal
- Journal of Climate Change

World Wide Web:

- www.ipcc.ch
- www.wmo.int
- www.unfccc.int.

MARINE GEOLOGY

Course code: Mar. Sci. 506
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of Course:

To give detailed overview of the structure, evolution and geological processes of the ocean basin and continental margin. This course will enable the students to fully understand the marine environment, what dynamic processes shape the surface of the earth under the ocean surface, sedimentation processes, and sediment distribution on seafloor.

Course Outline:

Development of Marine Geology, contribution of Deep Sea Drilling Project (DSDP), Integrated Ocean Drilling Programme (IODP), topography features of the ocean, plate tectonics and sea floor spreading. Major ocean basins, gulfs and seas. Geology of the continental margin. Estuaries, deltas, barrier islands and coral reefs. Sediment types and distribution. Shelf and deep sea sedimentation. Methods and instrumentation in marine geology/marine geophysics. Non-living marine resources.

Lab Outline:

Exercise of marine charts, navigation, bathymetry, marine acoustics, high resolution seismic, geography of marine environment. Sea floor spreading and plate tectonics. Marine sediments and seabed classification.

RECOMMENDED BOOKS:

1. Marine Geology: A planet Earth Perspective by Anderson, R.N.1986, John Wiley.
2. Marine Geology by James P. Kennett, 1982, Prentice-Hall, INC, Englewood Cliffs, N.J.
3. Initial Reports of the Deep Sea Drilling Project, Washington, D.C;
4. The Ocean Basins and Margins by Nairn, A.E.M and Stehli,F.G, 1973, The South Atlantic. Plenum, New York.
5. Oceanography, an introduction to the planet oceanus by Pinet Paul R. 1992, West publishing company, New York.
6. Laboratory Exercises in Oceanography 2nd Edition by Popkin, B.W, Grosline, D.S and Hammond, D.E., 1987, W.H. Freeman and Company. New York.
7. The Sea Floor: An In Introduction to Marine Geology by Seibold, E. and Berger, W.H., 1993, Heidelberg, Germany: Springer-Verlag.2nd edition.

Journals/Periodicals:

- Marine Geology
- Sedimentary Geology
- Sedimentology
- Deep Sea Research
- Continental Shelf Research

World Wide Web:

- http://www.rsmas.miami.edu/divs/mgg/
- http://marine.er.usgs.gov/index.php
- http://www.ngdc.noaa.gov/mgg/

MARINE CHEMISTRY

Course code: Mar. Sci. 507
Credit Hours: 3(2+1)
Prerequisites: Chemistry, Biology and Physics

Specific Objectives of the Course:

To understand concepts and development of Marine Chemistry.

Course Outline:

General introduction and history, Chemical composition of seawater, Physical properties of seawater (Structure, Chlorinity, Salinity, Refractive index, Electrical conductivity, Density, Temperature), Dissolved gases Solubility, distribution, Atmospheric exchange, CO_2 equilibria), Micronutrients (Composition, Distribution, Cycles), Minor and Major elements, Dissolved organic particulates, Radioisotopes, Primary secondry production in marine environment in relations to chemical constituents, Basic marine sedimentary constituents inorganic deepsea sediment, pelagic and non-pelagic

biogenous deep sea deposit, Chemical composition of deep sea sediments, Introduction to marine pollution.

Lab. Outline:

Seawater collection techniques, Sample collection and preservation, Salinity measurement, Analysis of seawater for dissolved gasses, nutrients and chlorophyll, Field visit

RECOMMENDED BOOKS:

1. Marine chemistry**:** an environmental analytical chemistry approach Antonio Gianguzza, Ezio Pelizzetti, Silvio Sammartano – 1997.
2. Marine Chemistry D. Satanarayana – 2007.
3. Marine Chemistry Chris Brightwell – 2007.
4. Marine chemistry**:** the structure of water and the chemistry of the hydrosphere Ralph Albert Horne – 1969.
5. J.P. Riley and R. Chester, 1971, Introduction to Marine Chemistry, Academic Press.
6. J.P. Riley and G. Skirrow, 1975, Chemical Oceanography, Academic Press.

Journals/Periodicals:

- Marine Chemistry
- Marine Pollution Bulletin
- Journal of Experimental and Marine Biology and Ecology
- Analytical Chemistry
- Deep Sea Research
- International Journal of Environment and Pollution
- Toxicological and Environmental Chemistry

COASTAL AND MARINE SEDIMENTOLOGY

Course code: Mar. Sci. 508
Credit Hours: 3(2+1)
Prerequisites: Mathematics

Specific Objectives of Course:

This course is designed to acquire the knowledge about various types of sedimentary environment and processes. This will help the students to understand the dynamics and natural processes involved in the coastal and marine system.

Course Outline:

Introduction to sedimentology, origin, transportation and deposition of sediments. Sedimentary structures, their classification, morphology and significance. Origin and classification of sedimentary facies. Provenance of sediments. Diagenesis. Concepts of sedimentary facies and facies associations. Physico-chemical controls of the sedimentary environments. *In-*

situ deposition of evaporates, authegnic and biogenic sediments.

Lab Outline:

Grain size analysis of sediments and sedimentary rocks. Megascopic and microscopic study of sedimentary rocks. Separation and identification of heavy minerals. Study of sedimentary structures.

RECOMMENDED BOOKS:

1. Sand and Sandstone by Pettijohn, F.J., Potter, P.E. & Siever, R.,1972, Springer.
2. Principles of Sedimentology by Friedman, G.M. & Sanders, J.E., 1978, JohnWiley.
3. Depositional Sedimentary Environments by Reineck, H.E. & Singh, I.B., 1980, Springer-Verlag.
4. Carbonate Sedimentology by Tucker, M.E. & Wright, V.P.,1990, Blackwell.
5. Sedimentary Environment and Facies by Reading, H.G., 1986, Blackwell.
6. Applied Sedimentology by Selly, R.C., 1988, Chapman & Hall.
7. Petrology of Sedimentary Rocks by Boggs Jr. S., 1992, Merril Publishing Co.
8. Sedimentary Rocks by Pettijohn, F.J., 1975, Harper and Row.
9. Sedimentary Geology by Prothero, D. & Schwab, F., 1996, W.H. Freeman & Co.

Journals/Periodicals:

- Sedimentology
- International Journal of Sediment Research
- Sedimentary Geology
- Deep Sea Research
- Continental Shelf Research

World Wide Web:

- www. walrus.wr.usgs.gov/seds
- www.sedimentologists.org/
- sedimentologist-liu.blogspot.com

MARINE GEOCHEMISTRY

Course code: Mar. Sci. 509
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

The course has been designed to provide background for and exposure to current research in marine geochemistry to understand the role of physical, chemical, biological processes in controlling chemical distribution in the marine environment.

Course Outline:

Sources and transport of material to the ocean (atmosphere, river, hydrothermal, relative flux magnitude). Ocean as reservoir (Nutrients, Organic carbon and carbon cycle, particulate material) in seawater. Formation, classification, distribution, chemical composition and chemical signatures of marine sediments. The geochemical cycle and the composition of ocean water. Trace elements in the ocean, Residence time and Reactivity of elements. The composition of oceanic suspended matter. The geochemistry of Marine sediments, Sediment interstitial waters and digenesis. Organic matter production, accumulation and preservation. Marine carbonates, Isotopes in marine Geochemistry. Chemical characteristics of Hydrothermal vent fluids, Geochemistry of Ferromanganese deposits in the ocean. Geochemical Proxies and global environmental history. Pollution in the sea. Geochemical models.

Lab. Outline:

Exercises Determination of Salinity, Residence time and Reactivity of Major Elements, Calculation of Chemical Fluxes, Paleo-productivity, Interpretation of Geochemical Proxies. Geochemical analysis of Marine Sediments

RECOMMENDED BOOKS:

1. Tracers in the sea by Broecker, W-S, Peng, T.H., 1982, Eldigio, Palisades.
2. Marine Geochemistry by Chester, R; 1990, Chapman and Hall, London.
3. Particle Flux in the Ocean by Ittekkot and et al (eds) 1996, Wiley and Sons. New York.
4. Sea water: Its Composition, Properties and Behavior by Gerry, B., ed, 1989, Pergamon Press plc Oxford and Open University Walton Hall, Milton, England.
5. Methods of Seawater Analysis, Grasshoff, K., Kremling, K. and Ehrhardt, M., 1999, Wiley-VCH, New York.
6. Ocean Biogeochemical Dynamics by Sarmiento, J. L. and N. Gruber, 2006, Princeton University Press
7. Marine Geochemistry by Schulz, H. D., and Zabel, M. (eds), 2002, Springer.
8. Coastal upwelling: Its sedimentary record, Part B: Sedimentary records of ancient coastal upwelling by Thiede, J and Suess, E (eds), 1983, Plenum Press. New York
9. Modern and ancient continental shelf anoxia by Tyson, R.V and Pearson, T.H. (eds); 1991, Geol. Soc. Spec. Publ; 58, Blackwell, Oxford.
10. Organic matter: Productivity, accumulation and preservation in recent and ancient sediments by Whelan, J.k and Farrington, J.W. (eds), 1992, Columbia University Press. New York.

Journals/Periodicals:

- Journal of Marine Research
- Deep Sea Research
- Continental Shelf Research

OCEAN BASIN EVOLUTION

Course code: Mar. Sci. 510
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of Course:

This course is designed to acquire the knowledge about the various types of plate boundaries, their kinematics and dynamics. This will help the students to understand the sea floor spreading and geological histories of the ocean basin.

Course Outline:

Platetectonics theory. Mechanism of platetectonics. Marine magnetic anomalies and sea-floor spreading. Individual ocean geological history. Heat distribution and age of the ocean crust. Island arc, back arc basins. Rocks of the ocean crust. Volcanism and oceanic ridges. Paleo-magnetism and plate stratigraphy. Oceanic ridges..Hot spot and Mantle plumes. Tectonic evolution of the ocean basins. Mineral resources.

Lab Outline:

Specified assignments/projects

RECOMMENDED BOOKS:

1. TectonicsbyMoores, E.M. & Twiss, R.J., 1995, W.H. Freeman and Co.
2. Global Tectonics by Keary, P. & Vine, F.J., 1996, Blackwell.
3. Plate Tectonics: How it Works by Cox, A. & Hort, R.B., 1986, Blackwell.
4. TheEvolvingContinentsbyWindley,B.F.,1984,JohnWiley&Sons.
5. Kereay, P., Klepeis, K.A. and Vine, F.J., 2009, Global Tectonics, Blackwell Scientific Publications.

Journals/Periodicals:

- Tectonics
- Tectono-Physics

World Wide Web:

- http://www2.env.uea.ac.uk/gmmc/igcp/oceanog.html
- http://www.agu.org/sections/tectonophysics/

COASTAL PROCESSES

Course code: Mar. Sci. 511
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

Study the effects of seawater movement on the coastal sediments, role of beach sediments in the protection of coasts, anthropogenic activities that alter the beach profile.

Course Outline:

Waves, tides, coastal currents. Distribution of sediment on the beach. Beach drift, Factors responsible for coastal erosion, coastal accretion, classification of sediments, sediment budget, coastal sediment transport, shoreline protection. Protection of chronically eroding beaches, types of hard stabilization for protection of coastal areas, Natural beach nourishment. Anthropogenic activities, beach management. Set back limits. Shifting of beach dunes. Sediments pathways in the Deep sea sedimentation, Minerals in the sediments. Formation of deltas. Barrier island formation, Options for Management of Coastal areas.

Lab. Outline:

Microscopic examination of beach sediments, identification of Biogenic oozes. Placer minerals, Sediment grain size analysis using a standard sieve shaker. Monitoring beach changes. Measuring beach slope. Case study of erosional beaches, creeks, islands etc.

RECOMMENDED BOOKS:

1. Coastal Processes**:** Concepts in Coastal Engineering and their. Application to multifarious environment by Tomoya Shibayama. World Scientific, 2009.
2. Coastal Processes**:** Volume 126; by C. A. Brebbia, G. Benassai, G. R. Rodríguez. WIT Publication 2009
3. Coastal Processes with Engineering Applications by Robert G. Dean,Robert A. Dalrymple. 2004. Cambridge University Press.
4. Coastal processes in tideless seas by . Kosian, Nikolaĭ Valentinovich Pykhov, Billy L. Edge. Ruben Derenikovich. ASCE Publications 2000.
5. Coastal lagoon processes by Björn Kjerfve. 1994.
6. Coastal and estuarine fine sediment processes by William H. McAnally, Ashish J. Mehta. 2001. Gulf Professional Publications.

Journals/Periodicals:

- Journal of Coastal research
- Journal of Estuarine & Coastal Research

World Wide Web:

- www.coastalprocesses.org
- www.geography.learnontheinternet.co.ukgeotopicscoasts
- http://www.seftoncoast.org.uk/shore_processes.html
- www.mbari.org/earth/Coastal/coastal.htm
- http://walrus.wr.usgs.gov/coastal_processes/

COASTAL ZONE MANAGEMENT

Course code: Mar. Sci. 601
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

To understand coastal zones, the dynamic environments shaped by natural forces as well as human intervention. To enable students to develop management strategies and identify threats to these environments.

Course Outline:

History, definition, systems view of the coast. Abiotic subsystems: classification of coasts, wave, current, sediment transport. Biotic subsystem: coastal ecosystems, eco-toxicology, marine pollution. Socio-economic subsystem: social, economic, legal and political dimensions. Coastal zone protection, beach nourishment, groins, revetments, breakwater, coastal embankment, cyclone shelter. Development options in the coast - tourism and recreation, fisheries, nature conservation. Policy analysis and case studies, coastal pressures, critical management issues and use conflict analysis - case examples, and use of GIS, global climate change, sea level rise and coastal adaptive management, fisheries issues & sustainable aquaculture.

Lab. Outline:

Case studies, Study of Regional legislation, Field trip to coastal areas and monitoring of beaches.

RECOMMENDED BOOKS:

1. An introduction to coastal zone management by Timothy Beatley, David J. Brower, Anna K. Schwab. 1994. 210 pages
2. Coastal zone management handbook by John R. Clark. 1996. 720 pages.
3. Coastal Zone Management By Parimal Sharma. 2009. 307 p
4. Integrated Coastal Zone Management by Erlend Moksness, Einar Dahl, Josianne Stottrup. 2009.

Journals/Periodicals:

- Coastal Management
- Journal of Coastal Conservation

World Wide Web:

- http://www.ess.co.at/ICZM/
- http://ec.europa.eu/environment/iczm/home.htm
- http://www.environment.gov.au/coasts/iczm/index.html
- http://www.lib.noaa.gov/retiredsites/docaqua/czm.html

MARINE POLLUTION AND CONTROL

Course code: Mar. Sci. 602
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

To understand pollution, its sources and implication with the biotic and abiotic environment.

Course Outline:

Introduction to marine pollution, chronic and acute inorganic and organic marine pollutants. Causes, effects and impacts on marine environment and humans. Health of the oceans, ocean disposal (marine outfalls, shipboard wastes, dumping of sludge, disposal of dredge spoil, radioactive wastes) and its impact. Marine pollution control and mitigation measurements; oil spills contingency plan and combating techniques.

Lab. Outline:

Seawater, sediment and marine organism analysis for different marine pollutants.

RECOMMENDED BOOKS:

1. Marine Pollution by R. Jhonston, 1976. Academic Press.
2. Marine Pollution and Its Control (McGraw-Hill series in water resources and environmental engineering) by Paul L. Bishop (1982).
3. Ocean Pollution: Effects on Living Resources and Humans (Marine Science) by Carl J. Sindermann (Hardcover - Nov 21, 1995).
4. Marine Pollution by R. B. Clark (2001).
5. Coastal Pollution: Effects on Living Resources and Humans (Marine Science) by Carl J. Sindermann (2005).
6. Protecting the Marine Environment from Land-Based Sources of Pollution: Towards Effective International Cooperation by Daud Hassan (2006).
7. Marine Pollution: New Research by Tobias N. Hofer, D. M. S. Abessa, V. M. C. Aguiar, and Juan A. Alfonso (2008).
8. Marine Environmental Pollution: Dumping and mining, Richard A. Geyer, 1981, Elsevier.

Journals/Periodicals:

- Marine Pollution Bulletin.
- Journal of Environmental Chemistry and Ecotoxicology.
- Marine Chemistry.

MARINE FISHERIES

Course code: Mar. Sci. 603
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:
Develop understanding of fisheries resources and management.

Course Outline:
History of fisheries, Aquatic resources, Gears and fishing techniques, Population dynamics and modeling , Fisheries data analysis, Fisheries management, Fisheries perspective of Pakistan , Conservation.

Lab. Outline:
- Study of fishing gears.
- Sampling design and methods of field collection.
- Identification of commercially important finfish and shellfish species.
- Assessment of maturation and spawning of commercially important species.

RECOMMENDED BOOKS:

1. Marine Fisheries Ecology. Simon Jenning, Michel J. Kaiser, 2001.
2. Hand Book of Marine Fisheries Conservation and Management, R. Quientin Grafton, Ray Hilborn, Dale Squires, 2010.
3. Responsible Fisheries in the Marine Ecosystem. Michael Sinclair, Grimur Valdinmarsson, Food and Agriculture Organization of the United States, 2003.
4. Improving the Collection Management and use of Marine Fisheries Data. National Research Council (US) Ocean studies Board, 2000.
5. Restoring and Stock Enhancement of Marine Invertebrate Fisheries. Johann D. Bell, Peter C. Rothlisherg, John L., Munro, 2005.

Journals/Periodicals:
- Journal of the Fisheries Research Board of Canada
- Fishery Bulletin
- Journal of Fish Diseases
- Journal of Fish Biology
- Journal of Fishery and Aquatic Sciences

FUNCTIONAL BIOLOGY OF MARINE ORGANISMS

Course code: Mar. Sci. 604
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

To understand anatomical and taxonomical features and vital functions of major invertebrates, vertebrates and plants.

Course Outline:

Comparative study of anatomical and taxonomical features and vital functions of major invertebrates and vertebrates, Life histories, defense mechanism and predation, food capture and choices, reproduction, respiration, osmoregulation and excretion, locomotion. Trophic relationship, ecology and adaptation.

Comparative study of anatomical and taxonomical features and vital functions of marine plants (phytoplankton, seaweeds and mangroves). Factors effecting plant growth in the oceans. Photosynthesis and nitrogen fixation, growth and productivity, useful chemicals from plants.

Lab. Outline:

Dissection of type specimens of marine animals (fish, crab, shrimp, polycheates), study different systems.

RECOMMENDED BOOKS:

1. The biology of Marine Mammals, Herald T. Anderson 1969, Academic Press.
2. Functional anatomy of marine mammals Volume 2, Richard John Harrison, 1972, Academic Press.
3. A functional biology of marine gastropods R.N. Hughes. 1986. Croom Helm. The University of California.
4. A functional biology of free-living protozoa Laybourm-Parry, 1984, University of California Press, Berkley Los Angeles.
5. Introduction to the biology of marine life. James L. Sumich and John F. Morrissey. 2004. Johns and Bartlett Publisher, Canada.
6. Biology of marine plants, 1990, Margaret N. Clayton, Longmann Cheshire.
7. Marine botany, 1988, Clinton J. Dawes.
8. Introduction to Phycology, 1987, Graham Robin South, Alan Whittick
9. Microalgae, 1994, E. Wolfgang Becker.
10. Algae and their biotechnological potential, 2001, Feng Chen, Yue Jiang.

OCEANOGRAPHIC INSTRUMENTS AND METHODS

Course code: Mar. Sci. 605
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

To understand principles and function of the instruments used in oceanography.

Course Outline:

Introduction to the principles of the instruments, Brief account of the following: time and position measurements (clocks, time signals, ground- and satellite-based navigation, attitude sensors), data logging (analog and digital recorders, telemetry, memory and recording, water properties measurements (temperature, conductivity, oxygen, optical properties, tracers and dyes), seabed sampling (grabs, corers, ROVs, underwater cameras), current measurements (mechanical, acoustic, electromagnetic, optical, radar, drifters), pressure and sea level measurements, mechanical technology (cables, winches, buoys, anchors).

Lab Outline:

Short field deployment of available instrument, and analyzing the resulting data.

RECOMMENDED BOOKS:

1. Handbook of ocean and underwater engineering, McGraw-Hill Book Co., New York (1969).
2. Baker, D.J., 'Ocean instruments and experiment design,'' in Evolution of physical oceanography, ed.
3. B.A. Warren and C. Wunsch, pp. 396-433, The MIT Press, Boston (1981).
4. Berteaux, H.O., Buoy engineering, pp. 1-319, John Wiley & sons, New York (1975).
5. Bowditch, N., American practical navigator, U.S. Defence Mapping Agency (1984).
6. Dobson, F., L. Hasse, and R. Davis, Air-sea interactions: instruments and methods, pp. 1-801, PlenumPress, New York (1980).
7. Ulrick, R.J., Principles of underwater sounds, pp. 1-384, McGraw-Hill Book Co., New York (1975).
8. Laboratory Exercises in Oceanography 2nd Edition by Popkin, B.W, Grosline, D.S and Hammond, D.E., 1987, W.H. Freeman and Company. New York.

Journals:

- Journal of Geophysical Research (Ocean), American Geophysical Union

- EEE Journal of Oceanic Engineering, Institute of Electrical and Electronics Engineers.
- Journal of Oceanic and Atmospheric Technology, American Meteorological Society.
- Deep-Sea Research, section B, Instruments and Methods, Gordon and Breach.

GEOLOGY OF THE ARABIAN SEA

Course code: Mar. Sci. 606
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of Course:

The primary goal is to provide background and exposure to current geological knowledge of Arabian Sea. To acquaint students with Arabian Sea geology and its resources prospects. This will pave the way for better exploration and management of offshore environment.

Course Outline:

Geological evolution of Arabian Sea. Geology of the coastal regions of Arabian sea. Physiographic and structural features of Arabian sea. Geo-dynamics and sedimentation of Makran and Indus continental margins. Geology of the Indus delta and Indus Fan systems. Geology of DSDP and ODP-Well sites from Arabian sea. Seismic stratigraphy of the northern Arabian sea. Mineralogy and geochemistry of Arabian sea sediments. Sea level changes, Oxygen Minimum Zone variations and its influence on Arabian sea sediments. Sedimentary record of climatic variations and Himalayan orogeny. Offshore hydrocarbon and Mineral resource prospects.

Lab Outline:

Selected Exercises based on national and international Geological research Cruises data of Arabian sea.

RECOMMENDED BOOKS:

1. Marine Geology and Oceanography of Arabian Sea and Coastal Pakistan by Haq, B.U. and Milliman, J.D. (eds) 1984, Van Nostrand Reinhold, New York.
2. Initial Reports of the Deep Sea Drilling Project, 1975. Vol. 23 by Whitmarsh, R.D; et al., (eds) 1975, Washington, D.C; U.S. Government Printing Office.
3. Trench and Fore-arc Geology: Sedimentation and Tectonics on modern and Ancient active Plate margin by Legget, J.K. (ed) 1982, Blackwell Scientific. Oxford.
4. The Ocean Basins and Margins, 6. The Indian Ocean by Nair, A.E.M. and Stehli, F.G (eds) Plenum, New York.

5. The Tectonic and Climatic Evolution of the Arabian Sea Region by P.D.Clift, D.Kroon, C.Gaedicke and J. Craig; 2005, Geological Special Publication No.195.
6. Seismic Facies and Sedimentary Processes of Submarine Fans and Turbidite Systems by Weimer, P and Link, M.H (eds) 1991, Springer, New York.

Journals/Periodicals:

- Marine Geology
- Deep Sea Research
- Continental Shelf Research
- Pakistan Journal of Oceanography

World Wide Web:

- www.iodp.org
- www.ngdc.noaa.gov
- www.niopk.gov.pk
- www.abdn.ac.uk/~gmi488/Site/Indus_River.html

DETAILS OF ELECTIVE MODULES

Module 1 Aquaculture

AQUACULTURE SYSTEM

Course code: Mar. Sci. 611
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

This course will enable to understand different culture systems, their designs and operations. Understanding the requirement of each system, its feasibility will help develop a feasible culture system in a given area.

Course Outline:

Introduction to development of aquaculture systems: design, construction and operation, feasibility and economics of marine invertebrates and vertebrates (Fish, crustaceans, mollusks, etc.). Recirculating water system: advantages and disadvantages, types and economic considerations.

Types of culture systems: Pond culture: Scope and objectives, types of ponds, design and construction, soil properties, water budget, fry rearing techniques, production rates, Harvesting and economic aspects. Cage and Pen culture: scope and objectives, types of ponds and cages, design and construction, selection of suitable site, cultivable species, farming operation and management.

Seaweed culture: Scope and objectives, culturing practices, site selection criteria, cultivable species, and procurement of seed, farming operation and management.

Hatchery design, operation and management, Water quality measurement and monitoring, Brood stock conditioning, spawning, rearing and harvesting.

Lab. Outline:

Assignment/case study on aquaculture systems, visits to aquaculture facilities.

RECOMMENDED BOOKS:

1. Aquatic Engineering (Mike Walker).
2. Sustainable Aquaculture by J.E Bardach. 1997
3. Intensive Fish Farming by Jonathan Shepherd and Niall Bromage 1992.
4. Fish Hatchery Management by G Wedemeyer 2001.
5. Cage Aquaculture by M. Beveridge. 2004

6. FAO Manual on Hatchery Production of Seabass and Gilthead Seabream by Alessandro Moretti and Mario Pedini Fernandez-Criado 2005
7. Responsible Marine Aquaculture. Edited by Stickney and JP McVey, 2002.
8. Aquaculture: Principles and Practices. T.V.R. Pillay and M. N. Kutty, 2005.
9. New species and technology development.
10. Recirlculating Aquaculture Systems (M. B. Timmons). 2002.
11. Principles of Aquaculture (Robert R. Stickney 1994).

Journals/Periodicals:

- Aquaculture Engineering (Elsevier).
- Aquaculture.
- Aquaculture Research.
- Journal of World Aquaculture.

HATCHERY OPERATION AND MANAGEMENT

Course code: Mar. Sci. 612
Credit Hours: 3(2+1)
Prerequisites: None

Course Outline:

Breeding criteria of marine species: taxonomy and morphology, life history, food and feeding habits, reproductive development, fecundity and spawning, Hatchery design: species consideration, site selection and hatchery size, Water quality management, Hatchery facilities and equipment.

Hatchery operations: brood stock collection and rearing, spawning and fertilization, incubation and hatching, harvest and transport, plankton/ microalgal culture.

Lab. Outline:

Detailed study of established hatcheries, Taxonomy and biology of commecrially important species (fish, shrimp, crab, bivalves), Study of larval developmental stages (slide preperation and microscopic examination).

RECOMMENDED BOOKS:

1. Aquatic Engineering (Mike Walker).
2. Sustainable Aquaculture by J.E Bardach. 1997
3. Intensive Fish Farming by Jonathan Shepherd and Niall Bromage 1992.
4. Fish Hatchery Management by G Wedemeyer 2001.
5. Cage Aquaculture by M. Beveridge. 2004

6. FAO Manual on Hatchery Production of Seabass and Gilthead Seabream by Alessandro Moretti and Mario Pedini Fernandez-Criado 2005
7. Responsible Marine Aquaculture. Edited by Stickney and JP McVey, 2002.
8. Aquaculture: Principles and Practices. T.V.R. Pillay and M. N. Kutty, 2005.
9. New species and technology development.
10. Recirlculating Aquaculture Systems (M. B. Timmons). 2002.
11. Principles of Aquaculture (Robert R. Stickney 1994).

Journals/Periodicals:

- Aquaculture Engineering (Elsevier)
- Aquaculture
- Aquaculture Research
- Journal of World Aquaculture

AQUACULTURE NUTRITION

Course code: Mar. Sci. 613
Credit Hours: 3(2+1)
Prerequisites: None

Course Outline:

Introduction to aquaculture nutrition, Protein, lipid, carbohydrate, vitamin and mineral requirements, Nutritional pathology, Aquafeed ingredients, formulation, manufacture and storage, Aquafeed: risks and benefits, Live feed and algal culture, Feeding regimes and diet selection criteria. Brood stock and larval nutrition: energy partitioning for reproduction, dietary quality

Lab. Outline:

Nutritional evaluation of feed ingredients (total protein, lipids, carbohydrates and gross energy).
Feed formulation: calculation for protein and energy levels in manufactured feed.Live feed: Microalgal and zooplankton culture (media preperation, maintenance and examination) .

RECOMMENDED BOOKS:

1. Nutrition and Feeding of Fish, Second Edition (Aquaculture Series) Publisher: Springer; 2nd edition (November 30, 1998) ISBN-10: 0412077019 ISBN-13: 978-0412077012.
2. Plankton Culture Manual, Frank H. Hoff (Author) 160 pages, Publisher: Florida Aqua Farms Inc; 5th Rev edition (July 1999) ISBN-10: 0966296001 ISBN-13: 978-0966296006.
3. Handbook on Ingredients for Aquaculture Feeds J.W. Hertrampf, F. Piedad-Pascual, Sik Lee Ong 624 pages. Publisher: Springer; 1 edition (June 1, 2000)

ISBN-10: 9780412627606 ISBN-13: 978-0412627606 ASIN: 0412627604.

Journals/Periodicals:

- Aquaculture nutrition
- Aquaculture
- Aquaculture Research
- Journal of World Aquaculture

AQUACULTURE: ENVIRONMENTAL MANAGEMENT

Course code: Mar. Sci. 614
Credit Hours: 3(2+1)
Prerequisites: None

Course Outline:

Concepts of sustainability, scope, objectives and importance of sustainable development. Natural resource requirements: Land, water and biological resources. Technical and economic assessment: location and sitting requirement, market assessment, financial analysis, risk assessment, resource utilization, socioeconomic characteristics, and sustainability profile. Environmental interactions: Impact of environment on aquaculture, culture site characteristics, water quality, mangroves, harvesting of wild larvae, predators and impact of aquaculture on environment. Nutrient load of aquaculture: Nitrogen, phosphorus. Legal and institutional framework: Government policy, Stakeholders. Key issues in aquaculture: environmental context, aquaculture integrated with agriculture, quality of seed resources and social aspects. Aquaculture extension: Definition and objectives, extension models and tools, extension services, extension training.

Lab. Outline:

Assignment/ case study (Market analysis, environmental impact, legal framework etc.).

RECOMMENDED BOOKS:

1. Aquaculture Management, James Meade(Author) 220 pages Publisher: Springer; 1 edition (1989), Language: English ISBN-10: 0412077116 ISBN-13: 978-0412077111.
2. The Role of Aquaculture in World Fisheries: Proceedings of the World Fisheries Congress, Theme 6. Tor G. Heggberget, John G. Woiwode, Robert J., Jr. Wolotira (Editors). 244 pages Publisher: Science Publishers (December 1996).
3. Fish Hatchery Management by G Wedemeyer 2001.

AQUACULTURE HEALTH MANAGEMENT

Course code: Mar. Sci. 615
Credit Hours: 3(2+1)
Prerequisites: None

Course Outline:

Microbial diseases: bacteria (aerobic, anaerobic, Gram +ve and –ve, *Pseudomonas*, *Vibrio*); virus (Lymphocyctis, viral necrosis, pancreatic necrosis); Fungi (*Ichtyoophomushoferi* and other fungal pathogens).Parasitic diseases: Protozoan, Platyhelmenthes, Nemathelmenthes, crustacean.

Disease issue in aquaculture: principal pathogens, effects.Diagnosis of pathogens: clinical, post-mortem and histopathological examinations, serology.Control: addition of chemicals to water, addition of chemicals to feed, medication directly to fish, antibiotics and probiotics.Socio-economic effects of diseases of fish and shell-fish.

Lab. Outline:

Identification and microscopic examination of bacteria and fungus causing disease.
Identification and microscopic examination of common parasites causing disease.
Examination of Pathological type specimen and histological slides.

RECOMMENDED BOOKS:

1. Fish Diseases and Disorders Vol 1-3 Eds.: P.T.K. Woo, J. F. Leatherland and D. D. Bruno 1999, CABI Publishers.
2. Bacterial Fish Pathogens: Diseases of farmed and wild fishes. Brian Austin and D. A. Austin 1999, Springer.
3. Fish Disease: diagnosis and treatment. E. J. Noga 2000, Wiley-Blackwell Publishers.
4. Health Maintenance and principle diseases of cultured fish. J. A. Plumb 1999, Wiley and Blackwell.

Module 2 Marine Fisheries

ICHTHYOLOGY

Course code: Mar. Sci. 621
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

1. Recognize all major taxonomic groups of fishes and systematics of common fishes.
2. Understanding of basic anatomy and physiology, evolution and zoogeography of major groups of fishes of fishes.
3. Understanding of current issues concerning conservation and fisheries management.

Course Outline:

Introduction to Ichthyology, Anatomy and systems (movement, Respiration, Blood and its circulation, Buoyancy and Thermal regulation, Hydromineral balance, Feeding, nutrition, digestion and excretion, Growth, Reproduction, Sensory perception, Behaviour and communication). Systematics, Evolution, (Hagfishes and lampreys, Sharks, rays and chimaeras, Relict bony fishes, Teleost fishes), Marine zoogeography, Marine fish assemblages, Conservation and Invasive species.

Lab. Outline:

Identification of some common marine fishes. Study of general anatomy and systems (disection of some representative fishes).

RECOMMENDED BOOKS:

1. Ichthyology. Karl F. Lagler 1977, Wiely.
2. Biology of Fishes. Q. Bone and R. H. Moore 2008, Taylor and Francis.
3. Physiology of Fishes, D. H. Evans 1998, CRC Press.
4. Ichthyology: Recent research advances. D. N. Saksena 1999, Oscar Publication, India.

SEAFOOD HANDLING PROCESSING AND SAFETY

Course code: Mar. Sci. 622
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

Understanding of major food safety hazards and control, handling, storage and shelf-life of fishery product, International laws regarding food safety.

Course Outline:

Food safety hazardsusing HACCP principles, developing HACCP regulations, hazard analysis, critical control point (CCP) determination, monitoring CCP and verification procedures, sanitation control procedures, biological hazards- microorganisms/ pathogens, (yeasts, moulds, bacteria especially spore forming, viruses, non spore forming protozoa, food spoilage, parasites- worms, protozoans, Chemical hazards- naturally occurring and added (intentional and unintentional) food additives.

Lab. Outline:

Visit to fish harbour and fish processing industry. Report writing on the major fish processing issues and its control.

RECOMMENDED BOOKS:

1. Seafood safety, Processing and Biotechnology. F. Shahidi, Y. Jones and D.D. Kitts 1997, Technomic Publishers.
2. Safety and Quality Issues in Fish Processing. H. A. Bremner 2002, CRC Press.
3. Seafood Safety. F. E. Ahmed 1991, National Academic Press USA.
4. Seafood Safety: Economics of Hazard Analysis and Criticle Control Points (HACCP). J. C. Cato 1998, FAO Fisheries Technical Paper 381.
5. Seafood Quality: Safety and Health Application. F. Shahidi, K. Mayashita, U. Wanasudra 2010, Wiely and Blackwell.

FISHERIES TECHNIQUES AND METHODS

Mar. Sci. 623
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

Understanding of fishing gears and method, fishing policies, fish population assessment and statistical methods.

Course Outline:

Fishing gears and methods, Illegal fishing gears, Analysis of fish population data, Methods for estimating fish population parameters (age, growth, recruitment, mortality), Use of computer modeling in fisheries, Fisheries statistical methods.

Lab. Outline:

Study of fishing gears and operation.
Application of statistical method on fisheries data.
Computer modeling excersise.

RECOMMENDED BOOKS:

1. Fisheries Techniques. B. R. Murphy and D. W. Willis 1996, American Fisheries Society, USA.
2. Fish Catching Methods of the World. A. V. Brandt 2005, Willey and Blackwell Publishers.
3. An Introduction to Fishing Gear Technology. K. B. Lal 1969, Metropolitan Book Company India.
4. Ken Shultz's Fishing Encyclopedia. 1999, IDG Books Worldwide.

FISHERIES RESOURCES AND MANAGEMENT

Mar. Sci. 624
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

To understand fish and non-fish recourses, conservation and management.

Course Outline:

Coastal, demersal and pelagic resources, Non-fish resources, Commercially important species, Overexploitation and conservation of resources, protected areas, Environmental issues, Management issues and control, international laws related to fisheries practice and management.

Lab. Outline:

1. Study of important coastal, demersal and pelagic fish and non-fish recources.
2. Case study of overexploitation and conservation strategies.

RECOMMENDED BOOKS:

1. Quantitative Fish Stock Assessment: choice, dynamics and uncertainty. R. Hillborne and C. J. Walters 1992, Springer.
2. Fisheries Ecology and Management. C. J. Walters and S. D. Martell 2004, Princeton University Press.
3. Theory and Management of Tropical Fisheries. D. Pauly and G. I. Murphy (eds) 1982, Proceedings of ICLARM/CSIRO workshop 1981 Australia.
4. Surveys of Fisheries Resources. D. R. Gunderson 1993, Willey and Interscience.

Journals/Periodicals:

Fishery Bulletin, Scientific Publication Office, National Marine Fisheries Office, NOAA USA.

FISHERIES ECONOMICS AND MARKETING

Mar. Sci. 625
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

To understand economic perspective of fisheries, maximum economic yield, fisheries efficiency, failure and control.

Course Outline:

Economic perspective of fisheries management, Economics of fish, Maximum Economic Yield (MEY), Bio-economic modeling and MEY targets, Data for economic analysis for commercial fisheries, Measurement and analysis of efficiencies in fisheries, Understanding and measuring capacity in fisheries, Measuring productivity and decomposing profits in fisheries, Economic insight, problems, policy choices, challenges of uncertainty, Adaptive measurement, Fisheries failure and control.

Lab. Outline:

1. Analysis of maximum economic yeild.
2. Analysis of fisheries efficiency.

RECOMMENDED BOOKS:

1. Commercial Exploitation of Fisheries: production, marketing and finance strategies. H. Bhattachary 2002, Oxford University Press USA.
2. Marketing in Fisheries and Aquaculture. Ian Cheston 1991, Wiley.
3. Production and Marketing Management of Marine Fisheries in India. R. Sethiadhas 1997, Daya Publishing House India.
4. Economics of Fisheries Management. Lee G. Anderson 2004, The Blackburn Press.
5. Adaptive Management of Renewable Resources. Carl Walters 2002, The Blackburn Press.
6. Fish Markets and Fishermen: the economics of overfishing. S. Iudicello, M. L. Weber and R. Wieland 1999, Island Press.
7. Worldwide Crisis in Fisheries: economic models and human behaviour. Colin W. Clark 2007, Cambridge University Press.

Module 3 Conservation Biology

DIVERSITY OF LIFE

Mar. Sci. 631
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:
To understand diversity of life its interaction with each other; handing of ecological data.

Course Outline:
Overview of diversity of marine life., Interrelationship between animal, plant and their environment., Essential principles of experimental design, presentation, evaluation and interpretation of ecological data, Factors effecting diversity of life and habitat.

Lab. Outline:
Field study design and data collection.
Ecological data analysis for environmental impact assessment, diversity parameters (richness, evenness, etc.).

RECOMMENDED BOOKS:
1. Biology: the unit and diversity of life (Cecie Starr and Ralph Taggart, 2006; Thomson Learning Inc.).
2. Species Richness: patterns in the diversity of life (Jonathan Adams and Jonathan S. Adams, 2009; Springer).
3. The Diversity of Life: from single cell to multicellular organisms (Roberst Snedden, 2007; Heinenmann Lib).
4. Diversity of Oceanic Life: an evaluative review, (Melvin N. A. Petterson, 1992; Center of Strategic and International Studies).
5. Biodiversity Conservation: problems and policies, (Charles Perrings 1995; Kluwer Acad. Publ.).

CHEMISTRY AND BIOCHEMISTRY OF LIFE

Mar. Sci. 632
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:
To understand the chemical and physiological behaviour of cell

Course Outline:
Structure, evolution and simple biochemistry of cell, Cell physiology, Special topics in aquatic biochemistry (bioluminescence, osmoregulation, tolerance to extreme environments).

Lab. Outline:

Estimation of basic biochemical compounds (total proteins, lipids, carbohydrates).
Estimation of amino acids, fatty acids and sugars.
Estimation of total chlorophyll and other pigments in seawater.
Assessment of photosynthesis (light and dark bottle experiment).

RECOMMENDED BOOKS:

1. Biochemistry (Marry K. Campbell, 2007; Thompson Publ.).
2. Learning Principles of Biochemistry (Albert Lehninger and David Lee Nelson, 2005; W. H. Freemann).
3. Biochemistry (Geoffary L. Zubay, 1983; Addison-Wesley).
4. Aquatic Geomicrobiology (Donald E. Canfield and Erick Kristensen, 2005; Elsevier).
5. Oceans and Human Health (Eds. Patrick Walsh and Sharon L. Smith, 2008; AcademicPress).

BIOLOGY AND BEHAVIOUR OF MARINE ANIMALS AND CONSERVATION

Mar. Sci. 633
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

To understand behavior and biology of marine organisms with respect to their conservation.

Course Outline:

Study of different groups of animals and plants using live, skeletal and fossil casts (birds, mammals, turtles, other target groups), Behavior of target groups of animals and plants, Threats and issues of target groups and Conservation strategies.

Lab. Outline:

Visits to conservation sites/protected areas
Study of fossil specimen and skeletal materials
Assignment / case study.

RECOMMENDED BOOKS:

1. Marine Mammals: evolutionary Biology (Annalisa Berta and James L. Sumich, 2004; Academic Press).
2. Introduction to the Biology of Marine Life (James L. Sumich and John F. Morrissey, 2004; Johns and Barlett Publishers).

3. Marine Conservation Biology: the science of maintaining the sea's boundary, (Elliot A.Norse and Larry B. Crowder, 2005; Island Press).
4. Asian Marine Biology – 14 Hong Kong University Press 1997.
5. Biological Resources in the Electronic Age (Judith A. Bazler 2003; Greenwood Publishing Group).

CELL AND EVOLUTIONARY BIOLOGY

Mar. Sci. 634
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:
To understand evolution at cellular and molecular level.

Course Outline:
Evolutionary theory and genetical basis of evolution, Cell structure and function at molecular level, Structure and function of macro-molecules, nucleic acid and information storage, translation into RNA and protein., Control of gene expression, Cell signaling.

Lab Outline:

RECOMMENDED BOOKS:
1. Evolutionary Biology (Edward Bitter 1991; JAI Press).
2. Concepts of Genetics (William S. Klugg and Micheal R. Cummings 2002; Merill Publishing Co.).
3. Genetics (Denial L. Hartt and Elisabeth W. Johns 2009; Johns and Barlett Learning).
4. Statistical Genetics of Quantitative trades: linkage map and QTL (Rongling Wo and Chang-Xing Ma 2007; Springer).
5. Advanced Biology for You (Gareth Williams 2000; Nelson Thompson).

MARINE CONSERVATION ECOLOGY

Mar. Sci. 635
Credit Hours: 3(2+1)
Prerequisites:

Course Outline:
Extent of life forms and theory/practices behind maintaining biodiversity, Habitat level management: issues of habitat damage or loss, Basics of coastal zone management: management and co-management – local, regional and global perspective.

Lab. Outline:
Case studies: students are required to select a site or community, collect data, and design a management plan for that particular site or community.

RECOMMENDED BOOKS:

1. Conservation Biology: foundations concepts, applications, Fred V. Dyke2008, 2nd Edition, Springer.
2. Conservation Biology: an evolutionary-ecological perspective. M. E. Soule and B. A. Wilcox, 1980.
3. Fundamentals of Conservation Biology, M. L. Hunter and J. P. Gibbs, 2007, Blackwell Publishing.
4. Marine Conservation Biology: Science of maintaining the Sea's Biodiversity. Elliott A Norse and L. B. Crowder, 2005, Marine Conservation Biology Institute, USA.
5. Dynamic modeling for marine conservation. M. Ryth & J. Lindholm. Springer Verlag, USA.
6. Sea Turtles: A complete guide to their biology, behaviour and conservation. J. R. Spotila. 2004, Johns Hopkins University Press USA.
7. Coral Reef Conservation. I. M. Cote and J. D. Reynolds. 2006, Cambridge University Press.
8. Marine Mammal Ecology and conservation: A handbook of Techniques. I. L. Boyd, W. D. Bowen and S. J. Iverson, 2010. Oxford University Press.

Module 4 Chemical and Environmental Oceanography

MARINE AND ESTUARINE CHEMISTRY

Mar. Sci. 641
Credit Hours: 3(2+1)
Prerequisites: Basic Chemistry, Introduction to Marine Chemistry.

Specific Objectives of the Course:
To understand first-order processes that takes place within the sea and affects its chemistry. Understand the distribution of chemical species in seawater and sediments, chemical processes and interaction with the biological, geological, and physical processes in the oceans.

Course Outline:
Physical, chemical, and biological processes governing the chemical composition of sea water in estuarine, coastal and marine environment. Nutrient and carbon fluxes, interstitial water chemistry, sea surface layer chemistry, air-sea inter-action, analytical marine chemistry.

Lab. Outline:

Coastal and deep sea water sampling techniques and protocols; Extraction of water from marine and deep sea sediments, Preservation of water samples at seaorganic/In-organic chemical/Analytical techniques for sample analyses.

RECOMMENDED BOOKS:

1. Introduction to Marine Chemistryby J. P. Riley and R. Chester (1971).
2. Chemical Oceanography**,** Vol. 1- 10 (2nd Ed.) - J. P. Riley and G. Skirrow, eds, Academic Press (1975–1989).
3. Morel, F. M. and J. G. Hering (1993). Principles and Applications of Aquatic Chemistry. New York, Wiley Interscience. 588pp.
4. Riley, J. P. and G. Skirrow, Ed. (1974 and later). Chemical Oceanography. New York, Academic Press.
5. Chemistry in the Marine Environmentby R.E. Hester and R.M. Harrison (2000).
6. Marine Chemistryby Chris Brightwell(2007).
7. Chemical Oceanography and the Marine Carbon Cycleby Steven Emerson and John Hedges (2008).
8. Chemistry of Marine Water and Sediments (Environmental Science and Engineering/Environmental Science)by Antonio Gianguzza, Ezio Pelizzetti, and Silvio Sammartano (2010).
9. Marine Chemistry: An Environmental Analytical Chemistry Approach (Water Science and Technology Library)by Antonio Gianguzza, E. Pelizzetti, and S. Sammartano (2010).

Journals/Periodicals:

- Marine Chemistry
- Deep Sea Research I & II
- Continental Shelf Research

ENVIRONMENTAL ECOTOXICOLOGY

Mar. Sci. 642
Credit Hours: 3(2+1)

Prerequisites:

Introduction to Chemistry, Introduction to Marine Biology, Marine Ecology

Specific Objectives of the Course:

To acquire understanding of conservation of marine ecology and ecosystem; improvement of health of marine organisms and humans.

Course Outline:

Introduction to ecotoxicology, major environmental contaminants, bioaccumulation factors influencing bioaccumulations, uptake, biotransformation, de-toxification, elimination and accumulation, transfer to various tropic level and their impact, molecular effects on biomass, acute and chronic lethal effects to marine organisms and ecosystems.

RECOMMENDED BOOKS:

1. Environmental Toxicology, David A. Wright and Pamela Welbourn Cambridge University Press 2002.
2. Environmental Toxicology: Biological and Health Effects of Pollutants, Second Edition.
   Ming-Ho Yu, Ming-Ho Yu, Humio Tsunoda, 2004.CRC Press.
3. Introduction to Environmental Toxicology. Impacts of Chemicals Upon. Ecological Systems, W. G. Landis and M.-H. Yu. By P. G. Wells, 2000.

Journals/Periodicals:

- Ecotoxicology.
- Ecotoxicology and Environmental Safety.
- Journal of Environmental Chemistry and Ecotoxicology.

MARINE BIOGEOCHEMISTRY

Mar. Sci. 643
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

To understand ways in which the biological components influence and are influenced by their physicochemical environment.

Course Outline:

The Physical Chemistry of Seawater, the Crustal-Ocean-Atmosphere Factory, Salinity as a Conservative Tracer, the nature of Chemical Transformation in the Ocean. Gas Solubility and Exchange Across the Air-Sea Interface. The Redox Chemistry of Seawater. Organic Matter: Production and Destruction. Trace Elements in Seawater. The Chemistry of Marine Sediments. Classification of Sediments. Organic Biogeochemistry. Marine - estuarine science and Biogeochemical Cycles,Organic Matter Sources and Transformation, Trace Metal and Nutrient Cycling (marine nitrogen, phosphorus, sulphur) in marine, coastal and estuarine environment. Marine Carbon Cycle and Global Climate Change. Primary Productivity and Biogeochemical Cycles.

RECOMMENDED BOOKS:

1. Introduction to marine biogeochemistry. By Susan M. Libes - 2009 - 909 pages.
2. Biogeochemistry of Estuaries, by Thomas S. Bianchi, 2006, Oxford University Press.

Journals/Periodicals:

- Marine Chemistry
- Marine Ecology Progress Series

- Continental Shelf Research
- Deep Sea Research
- Environmental Chemistry

World Wide Web:

- http://www.ifm-geomar.de/index.php?id=21&L=1
- http://www.imber.info/

MARINE NATURAL PRODUCT CHEMISTRY

Mar. Sci. 644
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

The course will focus on identification of natural product chemistry of marine organisms (Plants and Animals) and their uses; and provide understanding of basic principles of biosynthesis and bioassay screening.

Course Outline:

Introduction of marine natural products, Bioactive metabolites of marine organisms (Plants and Animals) Bioactivity of marine organisms, Introduction to biosynthesis and isolation of bioactive metabolites, Salient features of Bioassay screening of organic components.

Lab. Outline:

Basic principles of techniques used for biosynthesis and bioassay screening for marine natural products.

RECOMMENDED BOOKS:

1. Bioactive marine natural products, D. S. Bhakuni, Diwan S. Rawat, 2005,Gulf Professional Publishing.
2. Chemistry of Natural Products, Sujata, V. Bhat, 2005, Narosa Publishing House.
3. Organic Chemistry of Natural Products, Ayodhya Sing, 2004, Campus Book International.
4. Medicinal Natural Products, Paul M. Dewick, 2002, John Wiley and Sons.
5. Biologically Active Natural Products, Stephen J. Cutler, 2000, CRC Press.
6. Marine natural products, Paul J. Scheuer, 1983, Academic Press.
7. Natural Products from Plants, Peter B. Kaufman, 1999, CRC Press.
8. Chemistry of Natural Products, Paul J. Scheuer, 1993, Cambridge University Press.
9. The Chemistry of Natural Products, R. H. Thomson, 1985, Blackie and Son Limited.

10. Bioassay Techniques for drug Development, Atta-ur-Rahman, M. I. Choudhary, W. J. Thomsen, 2001, Harwood Academic Publishers.
11. Natural Products, A laboratory Guide, Raphael Ikan, 1991, Academic Press.
12. Biosynthesis of Natural Products, Paolo Manitto, 1981, John Wiley and Sons.
13. Organic Chemistry, I. I. Finar, 1975, English Language Book Society.

MARINE ENVIRONMENTAL IMPACT ASSESSMENT

Mar. Sci. 645
Credit Hours: 3(2+1)
Prerequisites:

Specific Objectives of the Course:

To understand basic principles and methodology to assess possible impact (positive or negative) that a proposed project may have on the environment, consisting of the natural, social and economic aspects with special focus on coastal installations.

Course Outline:

Introduction and principles, nature and procedures (IEE, EIS, SEA, EIA). Purpose of environmental impact assessment with reference to coastal/ marine environment. National Environmental Laws, International Conventions and Protocols relevant to EIA. Scoping and Public Participation. Marine Baseline Surveys (Flora and Fauna), Coastal and marine ecology/ ecosystems, geomorphology of coast, ocean dynamics, air and noise pertaining to coastal areas. Risk analysis and management, mitigation measures, Environmental Management Plans with relevance to the project.

Lab. Outline:

Assignments.

RECOMMENDED BOOKS:

1. Environmental Impact Assessment: Practice and Participation, Kevin Hanna, 2009, Oxford.
2. Methods of Environmental Impact Assessment, Peter Morris, 2009 Taylor & Francis.
3. Handbook of Environmental Impact Assessment, Judith Petts, 1999, Wiley-Blackwell.
4. Environmental Impact Assessment, A. G. Colombo, 1992, Springer,
5. Introduction to Environmental Impact Assessment, Glasson, J., R. Therivel, A. Chadwick, 2005, Taylor & Francis.
6. Environmental Impact Assessment, R. R. Barthwal, 2002, New Age International.

7. Environmental Impact Assessment, Larry W. Canter, 1996, McGraw-Hill.
8. Protecting the oceans beyond national jurisdiction: strengthening the international law framework, Robin Warner, 2009,BRILL.
9. Theory and Practice of Transboundary Environmental Impact Assessment, C. J. Bastmeijer, Kees Bastmeijer, Timo Koivurova, 2008, Martinus Nijhoff Publishers.
10. Introduction to Environmental Impact Assessment, John Glasson, Riki Therivel, Andrew Chadwick, 2005, Taylor & Francis.
11. Environmental Impact Assessment: theory and practice, Peter Wathern, 2005, Routledge.
12. Environmental Impact Assessment (EIA): cutting edge for the twenty-first century, Alan Gilpin, 2005, Cambridge University Press.
13. Marine Structural Design, Yong Bai, 2003, Elsevier.
14. Environmental Impact Assessment: A Practical Guide, Betty Marriott, 1997, Mc Graw Hill.
15. Environmental Impact Assessment: a methodological perspective, Richard K. Morgan, 1998 Springer.

Journals/Periodicals:

- *Environmental Impact Assessment Review*
- *Impact Assessment and Project Appraisal*

World Wide Web:
http://www.gdrc.org/uem/eia/lecture-notes.html

Module 5 Marine Geology

MARINE NON-LIVING RESOURCES

Course code: Mar. Sci. 651
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of Course:

The ocean floor contains energy sources and raw materials. Energy is the most important resources at present, while raw materials are of regional importance. Main aim of this syllabus is to understand the potential economic value of ocean. The course is designed to provide the geologic background to the non-living resources.

Course Outline:

Introduction and Overview - Progress in offshore exploration technology. Non-living resources and geological environments. Non-living resources types, Origin and distribution. Hydrocarbons, Oceanic Hydrates, Minerals,

Building Material, Metals, Marine Energy Resources (Waves, Tides, OTEC Energy), Chemicals, Drugs. Metal deposits in the ocean. Coastal & marine mineral resources. placer minerals, sulfides, oxides and. metalliferous muds. Manganese nodules and cobalt crusts. Gas hydrate – crystalline gas hydrate – formation of gas hydrate and global oceanic distribution. Law of the Sea - International Seabed Authority.

Lab Outline:

Specified assignments.

RECOMMENDED BOOKS:

1. Coastal upwelling: Its sedimentary record, Part B: Sedimentary records of ancient coastal upwelling by Thiede, J and Suess, E (eds), 1983, Plenum Press. New York
2. Modern and ancient continental shelf anoxia by Tyson, R.V and Pearson, T.H. (eds); 1991, Geol. Soc. Spec. Publ; 58, Blackwell, Oxford.
3. Organic matter: Productivity, accumulation and preservation in recent and ancient sediments by Whelan, J.k and Farrington, J.W. (eds), 1992, Columbia University Press. New York.
4. Bentor Yk 1980. Marine phosphorites-geochemistry, occurrence, genesis. Soc Econ Palentol Mineral Soc Publ 29 Tulsa Oklahoma.
5. Metro.J.L.1965. The mineral resources of the sea. Elsevier.
6. Skinner, B.J; and K.K Turrekian. 1973. Man and the Ocean. Prentice-Hal.
7. Degens ET , Ross D.A (1969) Hot brines and recent heavy metal deposits in the Red sea. Springer.
8. Fischer AG, Judson S (Eds) 1975. Petroleum and global tectonics. University Press, Princeton.
9. Glasby GP (1977) Marine manganese deposits. Elsevier.
10. Journals/Periodicals

Journals/Periodicals:

- Journal of Marine Research.
- Deep Sea Research.
- Continental Shelf Research.

World Wide Web:

- http://www.isa.org.jm/en/home
- http://www.nautilusminerals.com/s/Home.asp
- http://www.immsoc.org/

INTRODUCTION TO MARINE GEOPHYSICS

Course code: Mar. Sci. 652
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of Course:

This A wide spectrum of marine geophysical exploration methods have been developed in last two decades. The range of application extends from marine resource exploration to scientific investigations in the deep ocean. Introduction to Marine Geophysics course is designed to provides students knowledge of basic field skills in applied marine geophysics. The aim is to introduce the basic physical principles of off shore exploration and practical application to the geophysical techniques. At undergraduate level marine science students will highly benefit from understandings the role of geophysics particularly in hydrocarbon and mineral exploration.

Course Outline:

Scope of Marine geophysics. Introduction to different geophysical techniques. Gravity, Magnetic, Electrical and Seismic methods. High resolution and low resolution geophysical methods. Offshore Geophysical logging for resource evaluation. Instrumentation and Usages. Introduction to geophysical data acquisition, processing and interpretation.

Lab Outline:

Analysis and interpretation of geophysical data, Seismic images interpretation and understanding of subsurface geological features.

RECOMMENDED BOOKS:

1. Applied Geophysics by W. M. Telford, L. P. Geldart R. E. Sheriff, 2010. Cambridge University Press; 2nd edition.
2. Introduction to Geophysical Exploration by Philip Kearey, Michael Brooks, Ian Hill; 2002. 3rd ed. Blackwell Scientific Publications, London.
3. Introduction to Well Logs and Subsurface Maps by Jonathan C. Evenick, 2008: PennWell Corp.; illustrated edition.
4. Introduction to Geophysical Prospecting by Dobrin, M.B. & Savit, C. H., 1988, McGraw Hill.
5. Basic Exploration Geophysics by Robinson, E.S. & Coruh, C., 1988, John Wiley and Sons.
6. Geophysical methods in geology by Sharma, P.V., 1987, Elsevier Scientific Publishing Company.

Journals/Periodicals

- Exploration Geophysics
- Marine Geology
- Deep Sea Research

- Journal of Geophysical Research

World Wide Web:

- http://www.seg.org/SEGportalWEBproject/portals/SEG_Online.portal?_nfpb=true&_pageLabel=home
- http://www.aseg.org.au/
- http://www.publish.csiro.au/nid/224.htm

PALEO-OCEANOGRAPHY

Course code: Mar. Sci. 653
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of Course:

This course is intended for advanced undergraduate and graduate students who are interested in learning about the history of the oceans and earth's climate.. Students will acquire a broad spectrum of geological approaches, including paleontology, geochemistry and stratigraphy, to interpret the history of oceans and how paleoclimate studies help to learn more about the workings of the climate system.

Course Outline:

Introduction to Paleoceanograhy. Global paleoceanographic evolution. Major Paleoceanographic and Paleoclimatic Events in ocean history, Paleomonsoons. Marine geological record, Geochemistry of ancient oceans. Past ocean chemistry and water mass tracers, Paleoceanograhy and Paleoproductivity Indicators, Carbon Isotopes and Oxygen Isotope in Paleoceanography. Pacific, Atlantic and Indian Ocean Paleoceanography, Oceanic History of Calcium Carbonate Compensation Depth.

Lab Outline:

Paleoclimatic reconstruction techniques and sources of paleo climatic information. Dating methods. Selected Paleoceanographic exercises of marine geological records.

RECOMMENDED BOOKS:

1. Marine Geology by James P. Kennett, 1982, Prentice-Hall, INC, Englewood Cliffs, N.
2. Fischer, G. & Wefer, (1999) eds Use of proxies in paleoceanography. examples from the South Atlantic. Springer-Verlag Berlin Heidelberg,
3. Elderfield H., (2006) ed. The oceans and marine geochemistry, Treatise on geochemistry vol 6. Elsevier.
4. Bradley, R.S., 1999. Chapt. 3.2.3, Uranium-series dating, p. 76-80, *Paleoclimatology*.
5. C. Hillaire-Marcel & A. de Vernal 2007 (Eds), Proxies in Late Cenozoic Paleoceanography, Elsevier, Pergamon.

6. Blum, P., 1997. Physical properties handbook: a guide to the shipboard measurement of physical properties of deep-sea cores. ODP Tech. Note.
7. R. A. Scrutton and M. Talwani, 1982. *The Ocean Floor*, John Wiley, New York.
8. Barun K. Sen 1999, Gupta Modern Foraminifera Kluwer, *Academic Publishers*.
9. Ruddiman, W. F., 2001. Earth's Climate: past and future. W.H. Freeman & Son.

Journals/Periodicals:

- Marine Geology
- Paleoceanography
- Quaternary Research
- Science,
- Journal of Geophysical Research,

World Wide Web:

- http://www2.env.uea.ac.uk/gmmc/igcp/oceanog.html
- www.iodp.org
- www.ngdc.noaa.gov.

INTRODUCTION TO THE QUATERNARY GEOLOGY

Course code: Mar. Sci. 654
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of course:

The Quaternary Period comprises the last 1.5 million years of Earth history, an interval dominated by climate fluctuations. Studies of Quaternary environments are increasingly important to understand the scale and rapidity of climatic and environmental changes in the modern world. This course will cover geologic evidence, that are used to reconstruct ocean and atmospheric conditions (e.g., temperature) through the Quaternary. Understanding of recent coastal deposits and coastal features within the context of Late Quaternary climate variability.

Course Outline:

Introduction to the Quaternary, Quaternary Stratigraphy – Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy, glacial-interglacial cycles, eustatic changes, The oceanic record, Pleistocene sea level, proxy indicators of paleoenvironmental/ paleoclimatic changes, Responses of geomorphic systems to climate, sea level and tectonics on variable time scales in the Quaternary,. Quaternary dating methods, radiocarbon chronology, annual (varves, tree rings), Milankovitch Orbital cycles, D-O / H-events & last glacial termination (i.e., 20 - 7 ka), Ocean Circulation, neotectonics and their applications to natural coastal hazard assessment.

Lab Outline:
Study of the coastal areas of Pakistan.

RECOMMENDED BOOKS:

1. Andersen, B. G., and Borns, Jr., H. W., 1994, The ice age world: Oslo, Norway, Scandiavian University Press, 208 p.
2. Ruddiman, W. F., 2000, Earth's climate: past and future: San Francisco, California, Freeman.
3. Siegert, M. J., 2001, Ice sheets and late Quaternary environmental change: New York, New York, Wiley, 231 p.
4. Williams, M., Dunkerley, D., De Deckker, P., Kerhsaw, P., and Chappell, J., 1998, Quaternary Environments (2nd edition): New York, Oxford University Press, 329 p.
5. Ehlers, J., and Gibbard, P. L., 2004, Quaternary glaciations, extent and chronology, part II: North America: Elsevier, Netherlands, Developments in Quaternary Science 2, Rose, J., Series editor, 440 p.
6. Quaternary geology: A stratigraphic framework for multidisciplinary work, Parts 1-4. By D. Q. Bowen Pergamon Press (1978).
7. Earth Surface Processes and Landforms (Chichester Quaternary geology: Proceedings of the 30th International Geological ByAn Zhisheng.

Journals/Periodicals:

- Journal of Quaternary Science (Harlow, U.K.)
- Quaternary Research (Seattle) (1970 to 1986 and 1996 to date)
- Quaternary Science Reviews (Oxford, U.K.)

World Wide Web:

- http://notendur.hi.is/oi/quaternary_geology.htm
- http://rock.geosociety.org/qgg/
- http://www.pages-igbp.org/

SEA LEVEL CHANGES AND COASTAL ZONES.

Course code: Mar. Sci. 655
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of Course:

The main aim is to understand the sea level changes processes and its effects on coastal environment. How a coastal system responds to different sea level variations scenarios. To understand the delicate and complex dynamics of costal zones in relation to recent rise in sea level and associated coastal dynamics.

Course Outline:
Sea level changes and causes, Eustasy and Isostasy, Regional and global effects of sea level changes. Effects of sea level changes on shorelines. Sea level Processes and indicators. Changes in coastal environments, Coastal dunes, Estuaries and Lagoons, Deltas. Physical processes, Coastal ecosystem, Human activities, Coastal issues.

Lab Outline:
Specifiedassignments/projects.

RECOMMENDED BOOKS:

1. Bird, E.C.F. and Schwartz, M.L. (eds.) 1985. The words Coastlines. Van Nostrand Rheinhold, New York.
2. Bird, E.C.F, 1984. Coasts, An Introduction to coastal geomorphology. Basil Blackwell.
3. Bird, E.C.F, 1985. Coastline Changes. Wiley interscience.
4. Basco, D.R.1982. Surf Zone Currents. MR-82-7, Coastal Eng.Res. Center, US Army.
5. Carter, R.W.G; 1988. Coastal Environments, An introduction to the Physical, Ecological and cultural systems of coastlines. Academic Press.

Journals/Periodicals:

- Coastal Management
- Estuarine and coastal shelf research
- Journal of coastal research

World Wide Web:

- http://www.loicz.org/
- http://www.ess.co.at/ICZM/
- http://ec.europa.eu/environment/iczm/home.htm
- http://www.environment.gov.au/coasts/iczm/index.html
- http://www.lib.noaa.gov/retiredsites/docaqua/czm.html

Module 6 Physical Oceanography

NATURAL HAZARDS AND THE OCEANS

Course code: Mar. Sci. 661
Credit Hours: 3
Prerequisites: None

Specific Objectives of the Course:
Broadly, course is designed to learn collection and analysis of scientific data with respect to natural hazards. To study the hazards, its history, trends and definitions. How and why places are hazardous, including the human

geographic processes that put people at risk. Understanding of human nature and responses to disasters, and how science can be applied in the face of such disturbance.

Course Outlines:

Energy Sources & Earth Interior, Bathymetry and Plate Tectonics, Plate Tectonics & Earthquakes, Tsunami, Volcanoes, Bathy Charts, Earthquakes/Volcanoes, Introduction of Atmosphere, its dynamics, Ocean Conveyor Belt, Ocean Dynamics, Ocean Storms, Ocean Waves, Waves as Hazards, Tides & Standing Waves, Ocean Currents, Hurricanes, Hurricane Dynamics, Hurricane Damage, Global Climate Change , Hurricane Forecasts, ENSO, Cooling and Warming, Anthropogenic Climate Change, Natural Climate Change.

RECOMMENDED BOOKS:

1. Natural Hazards; Earth's Processes as Hazards, Disasters, and Catastrophes by E. A. Keller and R. H. Blodgett. 2008. 512 pp.
2. Natural Hazards and Disasters by Donald Hyndman, David Hyndman.
3. Disasters, An Analysis of Natural and Human-induced Hazards by Ebert, C.H. 2008. 576 pages.
4. Dangerous Earth, An Introduction to Geologic Hazards by Murck, B.W., Skinner B.J., Porter S.C. 1997. 330 pp.
5. Natural Hazards by Bryant, E.A. 1991. pages: 294 + xvii.

Journals/Periodicals:

- Natural hazards
- Natural Hazards Review
- Natural Hazards Observer

World Wide Web:

- http://www.natural-hazards-and-earth-system-sciences.net/
- http://www.colorado.edu/hazards/o/
- www.naturalhazards.org/
- www.usgs.gov/natural_hazards/
- www.ngdc.noaa.gov/seg/hazard/hazards.shtml

OCEANOGRAPHIC INSTRUMENTATION

Course code: Mar. Sci. 662
Credit Hours: 3(2+1)
Prerequisites: None

Specific Objectives of the Course:

In-situ measurements constitute a major component of any oceanographic program. Despite advances in satellite measurements, collecting in-situ data remains a necessity to measure parameters not accessible remotely and to develop calibration algorithm for satellite instruments. It is important to

introduce oceanography graduate students to these instrumentation techniques.

Course Outlines:

Principles of the instruments, the physical processes involved, Measurement techniques in physical oceanography, including pressure, temperature, salinity, oxygen, optical sensors, current meters, navigation systems, ocean acoustics and mooring structures, time and position measurements, data logging, analog and digital recorders, telemetry, underwater acoustics transponders, SOFAR, water properties measurements, current measurements, pressure and sea level measurements, meteorological measurements (wind, humidity, temperature, rain, radiation, mechanical technology (cables, winches, buoys, anchors, releases, towers), sampling and analysis strategies (temporal sampling, time series analysis, spatial sampling, array design, spatial data analysis, data assimilation.

Lab Outline:

Research projects will be offered to the students to conduct research work in collaboration with National organizations such as NIO, KPT, PQA etc.

RECOMMENDED BOOKS:

1. Data analysis methods in physical oceanography by William J. Emery, Richard E. Thomson. 2001. 654 pages.
2. Handbook of ocean and underwater engineering, John J. Myers. McGraw-Hill Book Co., New York.1969.
3. Ocean instruments and experiment design by Baker, D.J.,in Evolution of physical oceanography, ed. B.A. Warren and C. Wunsch. 1981.
4. Buoy engineering by Berteaux, H.O.1976. 314 p.
5. American practical navigation by U.S. Defense Mapping Agency. Bowditch 2010. 896 pages
6. Air-sea interactions: instruments and method by Dobson, F., L. Hasse, and R. Davis.1980. 801 pp.
7. Marine corrosion: causes and prevention by Laque, F.L. 1975. 346 pages
8. Principles of underwater sounds by Ulrick, R.J. 1996. 444 pages

Journals/Periodicals:

- Journal of Ocean Technology
- Journal of Atmospheric and Oceanic Technology

World Wide Web:

- http://www.whoi.edu/science/instruments/
- http://www.agoenvironmental.com/Instruments.htm
- http://www.valeport.co.uk/

AIR-SEA INTERACTIONS

Course code: Mar. Sci. 663
Credit Hours: 3
Prerequisites: None

Specific Objectives of the Course:

Oceanic and atmospheric mixed layers including fluxes of heat, momentum, moisture and salt between the ocean and atmosphere; vertical distribution of energy sources and sinks at the interface including the importance of surface currents; forced upper ocean dynamics, the role of surface waves on the air-sea exchange processes and ocean mixed layer processes.

Course Outlines:

Laminar and turbulent flows; Reynolds stresses; Richardson's criterion for turbulence; principles of Prandtl's mixing length theory; Taylor's statistical theory and Kolmogoroffs similarity theory, Air Sea interaction at various scales; planetary and laminar boundary layer, surface layer and spiral layer; Sea surface as a lower boundary of air-flow and its geometry; wind field in the first few meters of the sea surface, wind structure in the maritime frictional layer; transfer of heat and water vapour; determination of air-sea fluxes; Obukhov Length Scales, Approximations, Role of SSTs, Precipitation and Evaporation, energy exchange and global heat and water budgets, convection and its role in tropical circulations, effects of upwelling and sinking on the ocean atmosphere system.

RECOMMENDED BOOKS:

1. Atmosphere-Ocean Interaction by Kraus, E.B., and J.A. Businger. 1994. 362 pages
2. Fluid Mechanics of the Atmosphere by Brown, R. A. 1990. 440 pp.
3. The Atmospheric Boundary Layer by Garratt, J. R. 1994. 336pp.
4. Atmospheric-Ocean Dynamics by Gill, A. E.1982. Academic Press, 662 p
5. The Dynamics of the Upper Ocean by Kraus, E. B. 1977.
6. Wave Dynamics and Radio Probing of the Ocean Surface by Phillips, O. M. and K. Hasselman. 1986.

Journals/Periodicals:

- Boundary-Layer Meteorology
- Journal of Geophysical Research
- Monthly Weather Review
- Journal of The Atmospheric Sciences

World Wide Web:

- www. ioc-unesco.org
- http://www.wmo.int

OCEAN DYNAMICS

Course code: Mar. Sci. 664
Credit Hours: 3
Prerequisites: None

Specific Objectives of Course:

The aim of this course is to help students, acquire an understanding of some of the basic concepts of fluid dynamics that will be needed as a foundation for advanced applications in ocean and atmospheric sciences and ocean engineering, etc. The emphasis is on fluid fundamentals, but with an atmosphere/ocean twist.

Course Outline:

Introduction to Fluid Dynamics, Kinematics of Fluid Flow, Eulerian and Lagrangian Representations of Flow, The Material Derivative Trajectories, Streaklines, and Streamlines, Cauchy-Stokes Theorem, The Velocity Gradient Tensor, Vortex Flows, Circulation, and Vorticity, Equations of motion of frictionless ocean currents; scale analysis, barotropic and baroclinic approximation; geostrophic currents in a stratified ocean, the 2 layer approximation and White-Margules equation; gradient currents and mass stratification; relative currents and slope currents; Ekman's theory, Sverdup, Stommel and Munk's theories; Waves, Beta Effect, Wave Kinematics Barotropic, Fixed Depth Rossby Waves, Shallow Water Equations, Shallow Water Gravity Waves, Inertia-Gravity Waves, Kelvin Waves, Rossby Waves, upwelling and sinking with special reference to the Indian ocean.

RECOMMENDED BOOKS:

1. Fluid Mechanics, by Kundu, P. K., and I. M. Cohen. 2004.
2. Introduction to Geophysical Fluid Dynamics by Cushman-Roisin, B.
3. Atmosphere-Ocean Dynamics by Gill, A. E. 1994.
4. Physical Fluid Dynamics by Tritton, D. J. 1988. 544 pages
5. Introductory Dynamical Oceanography by George L. and Pickard, S. Pond. 349 pages.
6. An Introduction to Dynamic Meteorology by Holton, J. R. Academic Press, 2004 - 535 pages

Journals/Periodicals

- Ocean Dynamics
- Journals of Marine Science
- Physical Oceanography
- Journal of Physical Oceanography
- Atmosphere-Ocean Dynamics

World Wide Web:

- www. ioc-unesco.org
- http://www.wmo.int/
- www.oceanographers.net

- http://artikel-software.com/blog/2006/11/06/physical-oceanography/
- oceanworld.tamu.edu/print/home/course_book.htm

OCEAN MODELING

Course code: Mar. Sci. 665
Credit Hours: 3(2+1)
Prerequisites: Mathematics and physics background.

Specific Objectives of Course:

This course provides an introduction to numerical methods used to solve the equations of ocean motion. Topics of course range from basic numerical concepts to general transport and shallow-water equations to ocean circulation models that are employed to understand weather and climate.

Course Outline:

Introduction, Classifications of PDE's and their properties, Equations of motion and heat transfer in the ocean, Parabolic, hyperbolic, and elliptic equations, Numerical approximation of derivatives, Numerical approximation of derivatives, Basic strategies: grid-point and series-expansion methods, Finite difference scheme, Taylor series expansions, Spectral methods, Finite element methods, Truncation error, Higher order derivatives, Stability properties of time differencing schemes, Finite difference solution of the Poisson equation using direct and iterative methods, Special advection schemes, Energetically consistent finite difference schemes, Ordinary differential equations (ODE), Runge-Kutta method, Finite volume methods, Initial/ boundary value problems, Steady diffusion-advection equation, Methods for solving two-dimensional shallow-water equations, A, B, and C spatial grid configurations, Time integration schemes, Splitting methods, Solutions of Linear equation systems, Turbulence models, Large scale ocean models, Data assimilation.

Lab Outline:

Work on assigned modeling problems and write a report for each. For the final project one can chose a topic of your interest, building on the material covered in the course. This project must include a written final report with a thorough discussion of numerical aspects, such as stability and error analysis.

RECOMMENDED BOOKS:

1. J. H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer Verlag Berlin Heidelberg New York, 2002.
2. D. Gottlieb, S. A. Orszag, Numerical Analysis of Spectral Methods Theory and Application, Society for Industrial and Applied Mathematics, 1977.

3. D. B. Haidvogel, A. Beckmann, Numerical Ocean Circulation Modeling, Imperial College Press, 1999.
4. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980.
5. U. M. Ascher, Numerical Methods for Evolutionary Differential Equations, Society for Industrial and Applied Mathematics, 2008.
6. Kämpf, Jochen, Ocean Modelling for Beginners, 1st Edition, Springer, 2010.

Journals/Periodicals:

- Journals of Marine Science
- Journal of Physical Oceanography
- Atmosphere-Ocean Dynamics

World Wide Web:

- www. ioc-unesco.org
- http://www.wmo.int/
- http://artikel-software.com/blog/2006/11/06/physical-oceanography/
- oceanworld.tamu.edu/print/home/course_book.htm

Annexure - A

COMPULSORY COURSES

COMPULSORY COURSES IN ENGLISH FOR BS (4-YEAR) IN BASIC & SOCIAL SCIENCES

English I (Functional English)

Objectives: To enhance language skills and develop critical thinking.

Course Contents:

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voices
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension:
Answers to questions on a given text

Discussion:
General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening:
To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills:

Urdu to English

Paragraph writing:
Topics to be chosen at the discretion of the teacher

Presentation skills:
Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books:

1. **Functional English:**

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492

2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

English II (Communication Skills)

Objectives: To enable the students to meet their real life communication needs.

Course Contents:

Paragraph writing
Practice in writing a good, unified and coherent paragraph

Essay writing
Introduction

CV and job application

Translation skills
Urdu to English

Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills
Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

RECOMMENDED BOOKS:

Communication Skills

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing
   1. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
   2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading
   1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
   2. Reading and Study Skills by John Langan
   3. Study Skills by Riachard Yorky.

English III (Technical Writing and Presentation Skills)

Objectives: To enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing
How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

RECOMMENDED BOOKS:

Technical Writing and Presentation Skills:

a) Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).

   2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
   3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills
c) Reading
   The Mercury Reader. A Custom Publication. Compiled by Northern Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Annexure - B

Pakistan Studies (Compulsory)

Introduction/Objectives:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.
2. **Government and Politics in Pakistan**

   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward
3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

RECOMMENDED BOOKS:

1. Burki, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign Policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.

5. Wilcox, Wayne.*The Emergence of Banglades.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno -National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

Annexure - C

ISLAMIC STUDIES
(Compulsory)

Objectives:

This course is aimed at:

1 To provide Basic information about Islamic Studies.
2 To enhance understanding of the students regarding Islamic Civilization.
3 To improve Student's skill to perform prayers and other worships.
4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses:

Introduction to Quranic Studies

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To *Sunnah*

1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction To Islamic Law & Jurisprudence

1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Islamic Culture & Civilization

1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quran & Science

Islamic Economic System

1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

Political System of Islam

1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

Islamic History

1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Social System of Islam

1) Basic Concepts Of Social System Of Islam

2) Elements Of Family
3) Ethical Values Of Islam

Reference Books:

1) Hameed ullah Muhammad, “Emergence of Islam” , IRI, Islamabad
2) Hameed ullah Muhammad, “Muslim Conduct of State”
3) Hameed ullah Muhammad, ‘Introduction to Islam
4) Mulana Muhammad Yousaf Islahi”.
5) Hussain Hamid Hassan, “An Introduction to the Study of Islamic Law” leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993).
7) Mir Waliullah, “Muslim Jurisprudence and the Quranic Law of Crimes” Islamic Book Service (1982).
8) H.S. Bhatia, “Studies in Islamic Law, Religion and Society” Deep & Deep Publications New Delhi (1989).
9) Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001).

Note: One course will be selected from the following six courses of Mathematics.

COMPULSORY MATHEMATICS COURSES FOR BS (4-YEAR)

(FOR STUDENTS NOT MAJOURING IN MATHEMATICS)

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level

Credit Hours: 3 + 0

Specific Objectives of the Course:

To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.
Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression.
Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices.
Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Recommended Books:

Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin.

Boston (suggested text), Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston.

Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston.

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)
Credit Hours: 3 + 0

Specific Objectives of the Course:
To prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.
Limits and Continuity: Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.
Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Recommended Books:

Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York.
Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text).
Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston.
Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA.

3. MATHEMATICS III (GEOMETRY)

Prerequisite(s): Mathematics II (Calculus)

Credit Hours: 3 + 0

Specific Objectives of the Course:
To prepare the students, not majouring in mathematics, with the essential tools of geometry to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Geometry in Two Dimensions: Cartesian-coordinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line.

Circle: Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.
Conic Sections: Parabola, ellipse, hyperbola, the general-second-degree equation

Recommended Books:

Abraham S, Analytic Geometry, Scott, Freshman and Company, 1969.
Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston.
Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6^{th} edition), 1986, PWS-Kent Company, Boston.

Annexure - E

INTRODUCTION TO STATISTICS

Credit hrs: 3(3-0)

Unit 1. **What is Statistics?**

Definition of Statistics, Population, sample Descriptive and inferential Statistics, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant digits, Rounding of a Number, Collection of primary and secondary data, Sources, Editing of Data. Exercises.

Unit 2. **Presentation of Data**

Introduction, basic principles of classification and Tabulation, Constructing of a frequency distribution, Relative and Cumulative frequency distribution, Diagrams, Graphs and their Construction, Bar charts, Pie chart, Histogram, Frequency polygon and Frequency curve, Cumulative Frequency Polygon or Ogive, Historigram, Ogive for Discrete Variable. Types of frequency curves. Exercises.

Unit 3. **Measures of Central Tendency**

Introduction, Different types of Averages, Quantiles, The Mode, Empirical Relation between Mean, Median and mode, Relative Merits and Demerits of various Averages. properties of Good Average, Box and Whisker Plot, Stem and Leaf Display, definition of outliers and their detection. Exercises.

Unit 4. **Measures of Dispersion**

Introduction, Absolute and relative measures, Range, The semi-Inter-quartile Range, The Mean Deviation, The Variance and standard deviation, Change of origin and scale, Interpretation of the standard Deviation, Coefficient of variation, Properties of variance and standard Deviation, Standardized variables, Moments and Moments ratios. Exercises.

Unit 5. **Probability and Probability Distributions.**

Discrete and continuous distributions: Binomial, Poisson and Normal Distribution. Exercises

Unit 6. **Sampling and Sampling Distributions**

Introduction, sample design and sampling frame, bias, sampling and non sampling errors, sampling with and without replacement, probability and non-probability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions. Exercises.

Unit 7. **Hypothesis Testing**

Introduction, Statistical problem, null and alternative hypothesis, Type-I and Type-II errors, level of significance, Test statistics, acceptance and rejection regions, general procedure for testing of hypothesis. Exercises.

Unit 8. **Testing of Hypothesis- Single Population**

Introduction, Testing of hypothesis and confidence interval about the population mean and proportion for small and large samples, Exercises.

Unit 9. **Testing of Hypotheses-Two or more Populations**

Introduction, Testing of hypothesis and confidence intervals about the difference of population means and proportions for small and large samples, Analysis of Variance and ANOVA Table. Exercises.

Unit 10. **Testing of Hypothesis-Independence of Attributes**

Introduction, Contingency Tables, Testing of hypothesis about the Independence of attributes. Exercises.

Unit 11. **Regression and Correlation**

Introduction, cause and effect relationships, examples, simple linear regression, estimation of parameters and their interpretation. r and R^2. Correlation. Coefficient of linear correlation, its estimation and interpretation. Multiple regression and interpretation of its parameters. Examples.

Recommended Books:

1 Walpole, R. E. 1982. "Introduction to Statistics", 3rd Ed., Macmillan Publishing Co., Inc. New York.

2 Muhammad, F. 2005. "Statistical Methods and Data Analysis", Kitab Markaz, Bhawana Bazar Faisalabad.

Note: ***General Courses from other Departments***

Details of courses may be developed by the concerned universities according to their Selection of Courses as recommended by their Board of Studies.