SCHOOL OF ENVIRONMENTAL AND NATURAL RESOURCE SCIENCES

SCHOOL OF ENVIRONMENTAL AND NATURAL RESOURCE SCIENCES

Introduction

The establishment of the School of Environmental and Natural Resource Sciences integrates the knowledge of sciences such as the environmental sciences, geology, biology and marine sciences. The school participates actively in realizing the national agenda in education that is to improve capacity building of scientists and technocrats. In order to achieve the goal, the school offers several Master and Doctor of Philosophy programmes that are focused on original research.

Research Areas and Degrees Offered

The School of Environmental and Natural Resource Sciences conducts research in various fields of study in biology, environment sciences, geology and marine sciences. These include plant and animal systematics, conservation biology, forest ecology, weed science, cytogenetics, air and water pollution, land use and its control, forest fires and forest ecology, pesticide resistivity, environment health and security, biological monitoring and environmental impact assessment, geology and engineering geophysics, basin analysis, petroleum geology, environmental geology, economic geology and industrial minerals, geotourism and conservation geology, regional geology, remote sensing and GIS, coral reef ecology and mangroves, invertebrate diversity, fishes, microbes, vulnerable seaweed phenomenon, climatic weather patterns related to El Nino and La Nina, geochemistry, heavy metals and radionuclides, remote sensing applications and GIS for monitoring coastal changes. At the graduate level, the school offers the following programmes:

a) Doctor of Philosophy Programmes

- Biology
- Botany
- Genetics
- Zoology
- Geology
- Ocean Sciences
- Environmental Sciences

b) Master of Science by Thesis

- Biology
- Botany
- Genetics
- Zoology
- Geology
- Ocean Sciences
- Environmental Sciences

c) Master of Science by Course Work

- Conservation Biology
- Entomology
- Management of Plant Genetic Resources
- Plant Systematic
- Engineering and Environmental Geophysics
- Engineering Geology
- Industrial Minerals

- Environmental Assessment and Monitoring
- Marine Sciences

Entry Requirements

Candidates applying for this program must possess:

Doctor of Philosophy Programmes

a) A Master's degree from Universiti Kebangsaan Malaysia or other universities approved by the Senate; or
b) Other relevant professional/vocational qualifications or related experience which are recognised as equivalent to a Master's degree in Science by the Senate; or
c) A First Class Honours Degree or equivalent to a Cumulative Grade Point Average (CGPA) not less than 3.67 from Universiti Kebangsaan Malaysia or other universities approved by the Senate; or
d) Other relevant professional/vocational qualifications or related experience which are recognised as equivalent to a Master's degree by the Senate.

Master of Science Programmes

a) A Bachelor's degree in Science with a good cumulative grade point average (CGPA) from Universiti Kebangsaan Malaysia or other universities approved by the Senate; or
b) Other relevant professional/vocational qualifications or relevant experience approved by the Senate; or
c) Other equivalent qualification to a Bachelor's degree in Science or other qualifications approved by the Senate;
d) Candidates with a lower CGPA could be considered based on his or her related research experiences in the field of study.

Programme Structure

Doctor of Philosophy

All candidates of this programme are required to register for the STPD6014 Research Methodology course and thesis for each semester until the end of the academic programme. Students are required to schedule meetings with their supervisor or postgradute committee for not less than 40 hours per semester for full time students and 20 hours per semester for part time students.

Master of Science

Thesis

Candidates are required to register and pass 10 credit hours of courses and submit a thesis on completion of their research project. This requirement for 10 credit hours of courses can be fulfilled by registering for any course at Master of Science level offered by the Schools in the Faculty of Science and Technology subject to mutual agreement with supervisor.

Students should arrange to meet with their supervisor or the postgraduate committee at least 26 hours every semester for full time students and 13 hours for part time students.

Course Work

Students should register and pass 40 credit hours within 12 months (2 semesters). These units comprise core and elective courses of which their ratio varies in accordance to the respective programmes. Core courses include STPD6014 Research Methodology (4 credit hours), Research Project I (4 credit hours) and Research Project II (6 credit hours).

DOCTOR OF PHILOSOPHY (BIOLOGY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered biological knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in biology which can contribute to other disciplines.
PO2: Have an in-depth knowledge in biology and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in biology effectively.
PO4: Competent in conducting research and development in biology and possess creative and innovative skills.
PO5: Possess moral, ethical and professional value sand show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

DOCTOR OF PHILOSOPHY (BOTANY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the botany knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who is the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in botanical science which can contribute to other disciplines.
PO2: Have an in-depth knowledge in botanical science and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in botanical science effectively.
PO4: Competent in conducting research and development in botanical science and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.

PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

DOCTOR OF PHILOSOPHY (GENETICS)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce graduates with intellectual aptitude and expertise in genetics.
PEO2: To inculcate the knowledge of genetics in career development.
PEO3: To apply knowledge in genetics to lead the way and contribute towards the progress in related fields to serve the needs and well being of society.
PEO4: To develop the ability of creative and critical thinking for knowledge advancement.
PEO5: To strengthen the ability to integrate genetics in a broader knowledge framework.
PEO6: To strengthen effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: Able to contribute key concepts in genetics, and related areas in the development of society and industries.
PO2: Able to apply knowledge and expertise in decision making and problems solving.
PO3: Able to critically design experiments, analyse, interpret and integrate data.
PO4: Possess sound scientific communication skills and able to work as a team.
PO5: Able to source, retrieve and use scientific information related to the discipline and possess skills necessary for life-long learning.
PO6: Aware of ethical and contemporary issues in genetics and related areas.
PO7: Adequately informed and able to address issues pertaining to safety of products and procedures which could pose risks to public health and the environment**.**
PO8: Able and ready to disseminate knowledge and expertise.

DOCTOR OF PHILOSOPHY (ZOOLOGY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce graduates with intellectual aptitude and expertise in zoology.
PEO2: To inculcate the knowledge of zoology in career development.
PEO3: To apply knowledge in zoology to lead the way and contribute towards the progress in related fields to serve the needs and well being of society.
PEO4: To develop the ability of creative and critical thinking for knowledge advancement.
PEO5: To strengthen the ability to integrate zoology in a broader knowledge framework.
PEO6: To strengthen effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: Able to contribute key concepts in zoology and related areas in the development of society and industries.
PO2: Able to apply knowledge and expertise in decision making and problems solving.
PO3: Able to critically design experiments, analyse, interpret and integrate data.
PO4: Possess sound scientific communication skills and able to work as a team.
PO5: Able to source, retrieve and use scientific information related to the discipline and possess skills necessary for life-long learning.
PO6: Aware of ethical and contemporary issues in zoology and related areas.

PO7: Adequately informed and able to address issues pertaining to safety of products and procedures which could pose risks to public health and the environment.
PO8: Able and ready to disseminate knowledge and expertise.

DOCTOR OF PHILOSOPHY (GEOLOGY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce graduates with intellectual aptitude and expertise in geology.
PEO2: To inculcate the knowledge of geology in career development.
PEO3: To apply knowledge in geology to lead the way and contribute towards the progress in related fields to serve the needs and well being of society.
PEO4: To develop the ability of creative and critical thinking for knowledge advancement.
PEO5: To strengthen the ability to integrate geology in a broader knowledge framework.
PEO6: To strengthen effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in geology which can contribute to other disciplines.
PO2: Have an in-depth knowledge in geology and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in geology effectively.
PO4: Competent in conducting research and development in geology and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

DOCTOR OF PHILOSOPHY (OCEAN SCIENCES)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the ocean science knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: Mastery of advance knowledge in ocean science.
PO2: Technical competence in marine science with the ability to employ scientific methods to design, conduct experiments, analyze statistically, interpret data and contribute new information in the field of ocean science.
PO3: Ability to identify problems in ocean science and to solve the problems critically, creatively and innovatively.
PO4: Ability to work independently as an individual and inter-dependently as in a team.

PO5: Ability to communicate effectively in verbal and in writing to the scientific and public communities.
PO6: Ability to obtain, manage and utilize the latest information systematically and effectively.
PO7: High motivation for life-long learning.
PO8: Ability to address issues on and understand the need of cultural and environmental ethics in society.
PO9: Basic knowledge in entrepreneurship and management to develop and commercialize research findings for a sustainable community and environment.

MASTER OF SCIENCE (BIOLOGY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the biological knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in biology which can contribute to other disciplines.
PO2: Have an in-depth knowledge in biology and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in biology effectively.
PO4: Competent in conducting research and development in biology and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

MASTER OF SCIENCE (BOTANY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the botany knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in botany which can contribute to other disciplines.

PO2: Have an in-depth knowledge in botany and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in botany effectively.
PO4: Competent in conducting research and development in botany and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

MASTER OF SCIENCE (GENETICS)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the genetics knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in genetics which can contribute to other disciplines.
PO2: Have an in-depth knowledge in genetics and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in genetics effectively.
PO4: Competent in conducting research and development in genetics and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

MASTER OF SCIENCE (ZOOLOGY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the zoology knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in zoology which can contribute to other disciplines.
PO2: Have an in-depth knowledge in zoology and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in zoology effectively.
PO4: Competent in conducting research and development in zoology and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

MASTER OF SCIENCE (GEOLOGY)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the geology knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in geology which can contribute to other disciplines.
PO2: Have an in-depth knowledge in geology and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in geology effectively.
PO4: Competent in conducting research and development in geology and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

MASTER OF SCIENCE (OCEAN SCIENCES)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the ocean sciences knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in ocean sciences which can contribute to other disciplines.
PO2: Have an in-depth knowledge in ocean sciences and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in ocean sciences effectively.
PO4: Competent in conducting research and development in ocean sciences and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

MASTER OF SCIENCE (ENVIRONMENTAL SCIENCES)

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To produce a graduate who has mastered the environmental sciences knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAM OUTCOME (PO)

PO1: A solid foundation in environmental sciences which can contribute to other disciplines.
PO2: Have an in-depth knowledge in environmental sciences and be able to identify problems and formulate corrective action.
PO3: Be able to apply and disseminate knowledge in environmental sciences effectively.
PO4: Competent in conducting research and development in environmental sciences and possess creative and innovative skills.
PO5: Possess moral, ethical and professional values and show a concern for the environment.
PO6: Capable of interacting and communicating effectively.
PO7: Possess good entrepreneurship and leadership skills.
PO8: Willingness to explore and practice life-long learning.
PO9: Possess a high degree of confidence, self-esteem and open mindedness.

Courses Offered

STPD6014	Research Methodology
STAP6014	Natural Resource Prospecting
STAP6033	Biogeography
STAP6043	Plant Diversity and Systematic
STAP6064	Geographical Information Systems & Remote Sensing
STAP6073	Environmental Management System
STAP6092	Environmental Ethics

STAP6974	Research Project I
STAP6986	Research Project II
STAB6013	Conservation Biology
STAB6034	Population & Community Ecology
STAB6054	Conservation Ethics & Legislation
STAB6084	Natural Resource & Environmental Economics
STAB6123	Taxonomic Data and Resource Management
STAB6134	Phylogeny, Diversity and Taxonomy of Cryptogams
STAB6143	Economic Botany and Ethnobotany
STAB6153	Plant Micromorphology and Anatomy
STAB6174	Principles and Methods of Phylogeny Reconstruction
STAB6614	Insect Systematic
STAB6624	Insect Ecology
STAB6633	Insect Morphology and Anatomy
STAB6644	Insect Pest Management
STAB6654	Insect Physiology
STAB6664	Medical and Urban Entomology
STAB6673	Molecular Entomology
STAB6903	Diversity of Plant Genetic Resources
STAB6914	Plant Breeding
STAB6924	Advanced Plant Biotechnology
STAE6013	Management of Lake Ecosystems and Wetlands
STAE6303	Procedure and Techniques in EIA
STAE6323	Assessment and Monitoring of Air and Water Quality
STAG6083	Hydrogeology
STAG6104	Analytical Techniques and Assessment of Industrial Minerals
STAG6113	Earth Resources
STAG6123	Upstream and Downstream Aspects of Industrial Minerals
STAG6143	Economics of Industrial Minerals
STAG6134	Geology of Industrial Minerals
STAG6154	Techniques in Industrial Mineral Exploration
STAG6213	Engineering Geology
STAG6224	Soil Engineering
STAG6234	Rock Engineering
STAG6243	Geohazard Investigation
STAG6314	Engineering Geophysics
STAG6324	Environmental Geophysics
STAG6334	Instrumentation and Field Geophysics
STAG6343	Geophysical Data Processing
STAG6353	Geophysical Data Interpretation
STAG6363	Hydrogeology and Contamination Process
STAL6013	Advance Marine Ecology
STAL6023	Mariculture
STAL6033	Marine Microbiology and Biotechnology
STAL6034	Data Analysis Methods in Marine Sciences
STAL6043	Management and Conservation of Marine Resources
STAL6103	Advance Marine Chemistry
STAL6213	Coastal and Estuarine Oceanography

Course Contents

STAP6014 Natural Resource Prospecting

The aim of this course is to identify the types and distribution of natural resources that exist on this planet. The term natural resource refers to both biotic resources (living organisms) and biotic resources (e.g. soil, water, limestone formations, petroleum, coal, gold etc.). The course will emphasize on the fact that natural resources need to be utilized by mankind. But at the same time, there needs to be some sort of balance between exploitation and conservation of these resources to minimize environmental destruction/degradation and meet the needs of future generations.

References

Botkin, D.B. & Keller, E.A. 2005. *Environmental Science: Earth as a Living Planet.* 3rd. Ed. New York: John Wiley & Sons, Inc.

Camp, W.G. & Daugherty, T.B. 1995. *Managing Our Natural Resources*. 3rd. Ed. USA: Delmar.

Tietenberg, T. 2006. *Environmental and Natural Resource Economics*. 7th. Ed. New York: Addison-Wesley Longman Inc.

UNDP, UNEP, World Bank & WRI. 2000. *World Resources 2001-2002: People and Ecosystems:The Fraying Web of Life*. Amsterdam: Elsevier Science.

STAP6033 Biogeography

Biogeography is a multidisciplinary science related to biology, geography, geology, paleontology and ecology. Biogeography seeks to answer basic question such as why are there so many living creatures. Why are they distributed in the way they are? Have they always occupied current distribution patterns? Is the present activity of human affecting these patterns? What are their prospects of future? In this course students will acquire knowledge on science of biogeography. This course is organized in four parts. The first part covers the ecological setting that includes geographical variation in physical environment and limits of species distribution. The second part involves the historical setting such as speciation, extinction, dispersal, endemism and reconstructing biogeographic histories. The third part covers distribution of taxa in space and time and the fourth part includes the ecological biogeography such as the equilibrium theory of island biogeography, island patterns and processes, and conservation.

References

Avise, JC. 2000. *Phylogeography: The History and Formation of Species.* Cambridge, Mass.: Harvard University.

Avise, JC. 2004. M*olecular Markers, Natural History, and Evolution.* Sunderland, Mass. : Sinauer Associates

Cox CB & Moore PD. 2005. *Biogeography: An Ecological and Evolutionary Approach.* Malden, MA : Blackwell Pub.

Huggett, JH. 2004. *Fundamentals of Biogeography*. London : Routledge.

MacDonald, G. 2003. *Biogeography: Space, Time, and Life.* New York : John Wiley & Sons.

STAP6043 Plant Diversity and Systematic

This course covers the introduction to the scope and importance of plant systematic to plant biodiversity highlighting the needs for plant identification, classification and to understand the practice of botanical nomenclature. A brief history of taxonomy and also the classification of systematic in the modern era is touched. Emphasis is given to understanding the concept of population, species, genus and family and other categories in the taxonomic hierarchy. The course also focuses on the nature, type and application of taxonomic evidences paying special attention to the traditional evidences as well as the modern molecular evidences such as

DNA. The course ends with some discussion on what the taxonomic institutions do and also what taxonomists normally practice.

References

Davis. P. H. & V. H. Heywood. 1973. *Principles of Angiosperm Taxonomy.* Robert E. Krieger Publishing Company

Heywood, V.H. 1976. *Plant Taxonomy. Studies in Biology*. No. 5. 2nd. Ed. Edwards Arnold.

Jeffrey, C. 1982. *An Introduction to Plant Taxonomy*. 2nd. Ed. Cambridge University Press.

Jeffrey, C. 1973. *Biological Nomenclature*. Edwards Arnold Publishers

Jones, Jr., S B. & A. E. *Luchsinger*. 1979. Plant Systematics. McGraw-Hill Book Company

Porter, C.L. 1967. *Taxonomy of the Flowering Plants.* 2nd. Ed. W.H. Freeman & Co., San Francisco.

STAP6064 Geographical Information Systems and Remote Sensing

This course is divided into three parts: i.e. remote sensing, geographical information system (GIS) and global positioning system (GPS). Students will be exposed to the theory and concept of remote sensing, geographical information system and global positioning system as technologies in digital mapping. The course also covers on spatial and non-spatial data processing and positioning of spatial location for spatial mapping purposes.

References

Charles Elachi & Jacob van Zyl. 2006. *Introducing To The Physics and Techniques of Remote Sensing.* New Jersey: John Wiley & Sons, Inc.

Hofmann-Wellenhof, B., Lichtenegger, H. & Collins, J. 2004. *Global Positioning System: Theory and Practice.* New York: Springer-Verlag Wien.

Karen Steede-Terry. 2000. *Integrating GIS and The Global Positioning Sys*tem. redlands: Esri Press.

Paul A. Longley, Michael F. Goodchild, David J. Maguire & David W. Rhind. 2005. *Geographical Information Systems and Science*. 2nd. Ed. Chichester: John Wiley & Sons Ltd.

Sharifah Mastura S.A. 1999. *Pengenalan Penderiaan Jauh*. Bangi: Jabatan Geografi UKM

STAP6073 Environmental Management System

The course discusses the approach in environmental management which emphasizes Environmental Management System (EMS). The basic elements of EMS will be discussed for example constructing environmental guidelines, carrying out objectives and targets, programme implementation to accomplish the objectives, monitoring and measurements of efficiency, and also to reevaluate the system in order to improve the overall achievements. Students will be introduced to a new paradigm in environmental management which is Environmental Management Standard ISO 14000 Series. Details that will be discussed comprises the history of the standard development, comparison between other environmental management system such as BS7750 and EMAS, important elements of organization assessment aspect, product and process assessment, certification process and the implementation in Malaysia.

References

Cascio, J., Woodside, G. & Mitchell, P. 1996. *ISO 14000 Guide: the new International Environmental Management Standards.* New York: McGraw –Hill.

Clements, R.B. 1996. *Complete Guide to ISO 14000*. Englewood Cliffs, New Jersey: Prentice Hall.

Hunt, D. & Johnson, C. 1995. *Environmental Management Systems: Principles and Practice.* London: McGraw-Hill Book Company.

International Organization for Standardization. 1994. *Committee Draft ISO/CD 14000 Environmental Management Systems-general Guidelilnes on Principle, Systems and Supporting Techniques.* Geneva: International Organization for Standardization.

Ritchie, I. & Hayes, W. 1998. *Guide to Impelementation of the ISO 14000 Series on Environmental Management.* Upper Saddle River, New Jersey: Prentice Hall.

STAP6092 Environmental Ethics

Many environmental problems today are linked to the problematics of ethics. Whether it is ethics (or lack of which) that is related to the cause of an environmental problem, or ethics that is made the basis to evaluate a situation or an attitude towards the environment. Ethics as a knowledge discipline is also used to analyse an environmental condition or policies relating to the environment. This course approaches ethics as a knowledge field that inquires into how value systems influence observations, attitude, evaluation and decision making. The emphasis of this course is on the application of ethics towards environmental concerns although it necessarily begins with basic discussions on ethics itself.

References

Donald VanDeVeer & Christine Pierce, (Ed.). 1994. *The Environmental Ethics and Policy Book.* Wadsworth.

List, Peter. 1993. *Radical Environmentalism*. Wadsworth.

Sue Hendler. 1995. *Planning Ethics.* CUPR: Rutgers University, New Brunswick. Nasr, Seyyed Hossein. Religion and the Order of Nature. Oxford University Press, 1996.

Rockefeller, S. C. & Elder, J. C. Eds. 1992. *Spirit and Nature: Why the Environment is a Religious Issue.* Boston: Beacon.

STAP6974 Research Project I

The research project will be carried out in two semesters consecutively and each candidate is expected to submit their report at the end of the second semester. The titles for the projects will be given by the respective lecturers who are responsible to guide the students during their studies. This project will be evaluated based on the proposal presentation and the progress of the project in the first semester.

STAP6986 Research Project II

The Research Project II is the continuation of the Research Project I where students in this semester are required to write a report in the form of a thesis on all the results gained from the two semester project. Evaluation will be on the outcome of the project and the way it is presented both in printed version and verbally. The project must be written according to the UKM format.

MASTER OF SCIENCE (CONSERVATION BIOLOGY)

Introduction

The Conservation Biology Programme provides an interdisciplinary curriculum that integrates an understanding of biological diversity with the economic and social dimensions of development. This programme is collaboratively taught by staff from various departments and faculties who share a common interest in the conservation of nature and natural resources. The broad-based approach allows graduates to pursue a wide range of career options including consulting, policy research, planning, land management, research and teaching. It is also targeted at working professionals wishing to update or acquire new skills in the field of conservation biology.

Entry Requirements

Candidates should possess a degree with a good CGPA from Universiti Kebangsaan Malaysia or other universities approved by the Senate in Biological Sciences. Graduates in other fields or lacking adequate background may be admitted but must have relevant experience related to conservation.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce a graduate who has a holistic understanding of conservation biology.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAMME LEARNING OUTCOME (PO)

PO1: Mastery of basic knowledge in Conservation Biology.
PO2: Ability to apply biological principles and techniques to the key questions of why, what, where and how to conserve.
PO3: Ability to identify and solve problems critically, creatively and innovatively.
PO4: Ability to work effectively as an individual and in teams.
PO5: Ability to communicate verbally and in writing with the scientific community and the public.
PO6: Develop statistical and analytical skills to manage and interpret data for conservation management and research.
PO7: High motivation for life-long learning.
PO8: Have a good understanding of the practical realities and key approaches in conservation management and decision making.

PO9: Basic knowledge in entrepreneurship and management with the aim to develop and commercialize research findings for a sustainable community and environment.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 credit hours, comprising 25 credit hours of core courses and 15 credit hours of elective courses. Candidates are encouraged to expand their individual interest through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSES	TOTAL
I	STPD6014 Research Methodology STAP6064 Geographical Information Systems & Remote Sensing STAP6974 Research Project I	STAB6054 Conservation Ethics & Legislation STAB6084 Natural Resource & Environmental Economics	20
II	STAP6033 Biogeography STAP6014 Natural Resource Prospecting STAP6986 Research Project II	STAB6013 Conservation Biology STAB6034 Population & Community Ecology	20
TOTAL	**25**	**15**	**40**

Courses Offered

STPD6014 Research Methodology
STAP6033 Biogeography
STAP6014 Natural Resources Prospecting
STAP6064 Geographical Information Systems & Remote Sensing
STAP6974 Research Project I
STAP6986 Research Project II
STAB6013 Conservation Biology
STAB6034 Population & Community Ecology
STAB6054 Conservation Ethics & Legislation
STAB6084 Natural Resource & Environmental Economics

Course Contents

STAB6013 Conservation Biology

The Earth is now in a critical period for the survival of its natural ecosystems and their plant and animal members. Conservation biology is a multidisciplinary science that has been developed to deal with this crisis. Conservation biology is not just about maintaining viable populations of all species. Conservation is also about moral philosophy, social justice, economics and politics. The course will be divided into a number of sections to reflect this multidisciplinary approach, namely the origins of conservation biology; biological diversity

and its importance; threats to biological diversity; protection, restoration and management of populations, species, habitats and ecosystems; and economics and sustainable development.

References

Dyke, F.V. 2008. *Conservation Biology: Foundations, Concepts, Applications*. Holland: Springer.

Groom, M.J. Meffe, G.K. & Carroll, C.R. 2005. *Principles of Conservation Biology*. 3rd. Ed. USA: Sinaues Associates.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosembaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., Soehartono, T., Stanley, S. & O'Brien, T. 2005. *Life After Logging: Reconciling Wildlife Conservation And Production Forestry in Indonesian Borneo.* Jakarta: CIFOR & UNESCO.

Primack, R.B. 2006. *Essentials of Conservation Biology*. 4th. Ed. New York: Sinauer.

Sodhi, N.S. & Brook, B.W. 2005. *Southeast Asian Biodiversity in Crisis.* Cambridge: University Press.

STAB6034 Population and Community Ecology

Population and community are the two most important subjects in ecology. Population ecology is the study of populations of animals and plants, a population being a group of interbreeding organisms, while community ecology is the study of any assemblage of populations in a prescribed area or habitat. In this course, populations are analyzed in terms of their variability, density, and stability, and of the environmental and other processes and circumstances that affect these characteristics. Among such determinants of a given population are birth and death rates; the distribution of ages and sexes; behavioral patterns of competition and cooperation; predator-prey, host-parasite, and other relationships with different species; food supplies and other environmental considerations; and migration patterns. Further, communities are analyzed based on traditional characteristics; diversity, dominance, growth form and structure, trophic structure and relative abundance; and described as distinctive living system with development and function. In analyses and assessment of populations and communities, mathematical models and indices that incorporate as many determinants and variables are used to predict the effect of change in any one determinant may have on a population and community.

References

Begon, M., Harper, J.L. & Townsend, C.R. 1996. *Ecology: Individuals, Populations and Communities.* 3rd. Ed. Blackwell Scientific Publications.

Begon, M. & Moritimer, M. 1996. *Population Ecology: A Unified Study of Animals and Plants*. 3rd. Ed. Blackwell Science Publications.

Giller, P.S. 1984. *Community Structure and The Niche*. Chapman and Hall.

Krebs, C.J. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance*. 4th. Ed. Harper and Row.

Stiling, P. 1999. *Ecology: Theories and Applications.* 3rd. Ed. Prentice-Hall Int.

STAB6054 Conservation Ethics and Legislation

Ethics and law are essential to conservation. The former sets the objective, and the latter the legal basis. This course will briefly introduce by way of background, the basic issues relating to conservation ethics and law. General ethical concerns, the evolution of laws relating to biological resources, habitat and ecosystems, at both global and national levels will be sketched. Various principles and concepts relating to biological conservation will also be discussed, to identify the inherent values (ethics). Institutional roles and functions will be outlined to describe the accountability and responsibility attached in implementing laws for conservation. The relationship between science, ethics and law will also be analysed in brief.

References

Alder, J. & Wilkinson, D. 1999. *Environmental Law and Ethics.* Macmillan: Press Ltd.
Dower, N. 1989. *Ethics and Environmental Responsibility.* Avebury.
LaFollette, H. (ed.). 2000. *The Blackwell Guide to Ethical Theory.* Blackwell Publishers.
Sands, P. 1995. *Principles of International Environmental Law.* Manchester: Manchester Press
Van Heijnsbergen, P. 1997. *International Legal Protection of Wild Fauna and Flora.* IOS Press.

STAB6084 Natural Resource and Environmental Economics

The course discusses the economic principles of natural and environmental resource conservation. Issues in sustainable economy of renewable and non-renewable resources, economic valuation of natural resource goods and environmental functions and their incorporation into a cost benefit analysis of development projects versus conservation will be given special attention. A discussion on the use of economic and market-based instruments to encourage natural and environmental resource conservation will be provided.

References

Abdul Hamid H. M. I. & Mohd Shahwahid H.O. 2005. *Penilaian Sumber dan Harta Tanah Hutan*. J.Bahru: Penerbit Universiti Teknologi Malaysia.
McNally, Richard & Mohd Shahwahid H.O. 2003. *Environmental Economics: A Practical Guide*. WWFUK
Mohd Shahwahid H.O. & Jamal O. 1999. *Economic costs to Malaysia.* Dlm. Glover, D. & Jessup, T. (ed.) hlm. 22-50. Bab 3 of Institute of South East Asian Studies (ISEAS) and Economy & Environment Program for Southeast Asia (EEPSEA) book on "Indonesia's Fires and Haze: The Cost of Catastrophe".
Mohd Shahwahid H.O. 1999 (ed.). Manual on Economic Valuation of Environmental Goods and Services of Peat Swamp Forests. Malaysian-DANCED Project on Sustainable Managementof Peat Swamp Forests, Peninsular Malaysia
Mohd Shahwahid H.O., Awang Noor A.G., Abdul Rahim N., Zulkifli Y. & Razani U. 1999. Trade-offs on Competing Uses of a Peninsular Malaysian Forested Catchment. *Environment and Development Economics* 4(4):281-314.

MASTER OF SCIENCE (ENTOMOLOGY)

Introduction

Entomology is a field of science specializing on all aspects of learning and studying of insects. Its importance to mankind cannot be denied in the highly sophisticated era and borderless world that we live in. This is because man can easily move freely and quickly from place to place and unintentionally carry with them insects that are potential pests or act as vector of disease in other countries. The effect of physical development that indirectly change the ecosystem, landscape and habitat in which insects live in can contribute to the reduction of insect diversity, loss of insect species that are highly sensitive to habitat changes, and most importantly can make insects become crop pests or become the cause of annoyance. As such, it is the responsibility of Universiti Kebangsaan Malaysia to train and produce Master of Science (Entomology) graduates with knowledge and skills to solve problems related to or caused by insects.

The Master of Science (Entomology) Programme by course work is offered to candidates interested in pursuing their studies in Entomology full-time (one year) or part-time (two years). The programme is designed in such as way that graduates have the opportunity to appreciate, understand and learn all aspects of insects especially those related to the role and contribution of insects to other related field of sciences, ecosystem stability, mankind and the

whole world. To achieve this target, students are required to take core and elective courses that are related to the study of insects. Additionally, they must also conduct a short research project. It is hoped that by taking these courses the graduates will be equipped with knowledge suited for Master of Science (Entomology) degree and will help them pursue careers as well as facilitate them to further their studies to Doctor of Philosophy level in the same or related fields.

Entry Requirements

Candidates for the programme by course work must possess the following:

a) Bachelor of Science (Zoology, Entomology or General Biology) degree with a good Cumulative Grade Point Average (CGPA) from University Kebangsaan Malaysia or other universities approved by the Senate.
b) Other qualifications equivalent to a Bachelor of Science (Zoology, Entomology or General Biology) degree and other qualification or working experience in relevant fields approved by the Senate.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce a graduate who has mastered the entomology knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAMME LEARNING OUTCOME (PO)

PO1: Mastery of basic knowledge in entomology.
PO2: Technical competence in entomology with the ability to employ scientific methods to design, conduct experiments, analyze statistically, interpret data and contribute new information in the field of entomology.
PO3: Ability to identify problems in entomology and to solve the problems critically, creatively and innovatively.
PO4: Ability to work independently as an individual and inter-dependently as in a team.
PO5: Ability to communicate effectively in verbal and in writing to the scientific and public communities.
PO6: Ability to obtain, manage and utilize the latest information systematically and effectively.
PO7: High motivation for life-long learning.
PO8: Ability to address issues on and understand the need of cultural and environmental ethics in society.
PO9: Basic knowledge in entrepreneurship and management to develop and commercialize research findings for a sustainable community and environment.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 credit hours, comprising 23 credit hours of core courses and 17 credit hours of elective courses. Candidates are encouraged to expand their individual interest through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSES	TOTAL
I	STPD6014 Research Methodology STAP6974 Research Project I	STAB6614 Insect Systematic STAB6624 Insect Ecology STAB6633 Insect Morphology and Anatomy	**19**
II	STAB6673 Molecular Entomology STAP6986 Research Project II	STAB6644 Insect Pest Management STAB6654 Insect Physiology STAB6664 Medical and Urban Entomology	**21**
TOTAL	**17**	**23**	**40**

Courses Offered

STPD6014 Research Methodology
STAP6974 Research Project I
STAP6986 Research Project II
STAB6614 Insect Systematic
STAB6624 Insect Ecology
STAB6633 Insect Morphology and Anatomy
STAB6644 Insect Pest Management
STAB6654 Insect Physiology
STAB6664 Medical and Urban Entomology
STAB6673 Molecular Entomology

Course Contents

STAB6614 Insect Systematics

The course will first discuss the introduction of systematics, its historical development and systematic activities including the systematics of Malaysian insects. Students will be exposed to ways on how to increase their knowledge on taxonomy by studying the principles and concepts of systematics which involve grouping, classification and naming according to the International Code of Zoological Nomenclature (ICZN). They will also be exposed to aspects of evolution, ecology, ethology, biogeography and other related aspects. To really understand the systematic activities, three major aspects will also be emphasized, namely the morphological characters, reproductive and molecule (DNA). An introduction and application of computer software such as PAUP will be taught especially in erecting a phylogenetic tree of a given insect group. Students will be requested to write taxonomic manuscripts and erect a phylogenetic tree of their own selected insect group or taxa, which in turn will be their term paper for this course.

References

Borror, D.J., Triplehorn, C.A. & Johnson, N.F. 1989. *An Introduction to The Study of Insects.* Philadelphia: Saunders College Publ.

Mayr, E. & Ashlock, P.D. 1991. *Principles of Systematics Zoology*. 2nd. Ed. New York: McGraw-Hill, Inc.

Romoser, W.S. & Stoffolano, J.G. 1998. *The Science of Entomology*. Boston: WCB McGraw-Hill.

Swofford, D.L. 1991. *PAUP: Phylogenetic Analysis Using Parsimony.* Version 3.1. Illinois: Illinois Natural History Survey.
Wiley, E.O. 1981. *Phylogenetics: The Theory and Practice of Phylogenetic Systematics.* New York: John Wiley & Sons, Inc.

STAB6624 Insect Ecology

This course will discuss the habit and role of insects from an ecological perspective. The discussion on the ecological aspects that cover insect growth, development, survival, reproduction, role of host, abiotic and biotic factors, adaptation, genetic variation, life support system and distribution pattern in nature and for application perspective will be heavily emphasized. The concept of insects in ecosystem, diversity and tropic structure, role as decomposer, pollinator, vector and the dynamic and regulator of insect pest population will also be discussed. The diversity and conservation aspects with examples of highly valuable insects ecologically, economically, medicinal and aesthetic as well as those of protected species will also be discussed.

References

Huffaker, C.L. & Gutierrez, A.P. 1999. *Ecological Entomology.* 2nd. Ed. New York: John Wiley & Sons.
Price, P.W. 1997. *Insect Ecology.* 3rd. Ed. New York: John Wiley & Sons.
Showalter, T.D. 2000. *Insect Ecology: An Ecosystems Approach.* London: Academic Press.
Speight, M.R. & Wylie, F.R. 2001. *Insect Pests in Tropical Forestry.* London: CABI Publ.
Travor Beebee. 2004. *An Introduction To Molecular Ecology*. Oxford Univ. Press.

STAB6633 Insect Morphology and Anatomy

This course discusses external and internal structure of insects as insects (arthropods with body divided into 3: head, thorax and abdomen) that have basic structures and appendages with modifications/ adaptations which enable insects to function, survive, and adapt as organisms most successful and diverse on this earth, in the context as basic understanding of insect biology, ecology, classification and physiology. Of those discussed include: structure, body wall (exoskeleton), segmentation; structure and appendages in head (including eyes, antennae, mouthparts and feeding mode adaptation), thorax, (including wings and flight, legs and movement, spiracles and respiration) and abdomen (including spiracles, reproductive appendages, genitalia and non-reproductive). Exposed includes knowledge of internal structures: endoskeleton, muscular system, (and movement); digestive system (according to feeding mode); circulatory system (opened and blood); respiratory system (tracheal, terrestrial, aquatic and parasitic); excretory system; reproductive system (male and female) and development; nervous system (and sensory organs).

References

Norman F. Johnson & Charles A. Triplehorn 2004. *Borror and Delong's Introduction To The Study of Insects.* 7th. Ed. New York: Saunders College Publishing.
Chapman, R. F. 1998. *The Insects: Structure and Function*. 4th. Ed. Cambridge: Harvard University Press.
Blum, M. S. 1985. *Fundamentals of Insect Physiology.* New York: John Wiley and Sons Inc.
Kerkut, G.A. & Gilbert, L. I. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology.* Vol. 1 - 12. Oxford, New York: Pergamon Press.
Roeder, K. D. 1985. *Insect Physiology.* New Delhi: International Books & Periodicals Supply Service Publication.

STAB6644 Insect Pest Management

This course will discuss the principles of Integrated Insect Pest Management (IPM). The important components that ensure the success of IPM, such as basic biology, ecology, insect behavior, biotic and abiotic factors, types of damage, economic threshold levels, monitoring, sampling, strategies and techniques of pest control that are environmental friendly using biological control agents (predators, parasitoids, pathogens and microbial insecticides) will be discussed. Students will also be introduced to the concept of on-line and modeling development for 'Integrated Pest Management Program' (IPM), and how best to implement (including on aspects of agricultural law) and evaluate socially, politically and environmentally acceptable in a borderless economic era. The law of pesticide development, usage and selling and aspect of insect quarantine will also be discussed. Additionally, students will be introduced to contributions of biotechnology methods and techniques to the progress and success of IPM. At the end of the course students are required to develop an IPM for the current three species of major insect pests of their selected crops.

References

Croft, B.A. 1990. *Arthropod Biological Control Agents and Pesticides.* London: John Wiley & Sons, Inc.

Dent, D. 2000. *Insect Pest Management.* 2nd. Ed. London: CABI Interl.

Marshall, G. & Walters, D. 1994. *Molecular Biology in Crop Protection.* London: Chapman & Hall.

Olkowski, W., Daar, S. & Olkowski, H. 1993. *Common-sense Pest Control.* Newtown: The Taunton Press.

Tanada, Y. & Kaya, H.K. 1993. *Insect Pathology.* San Diego: Academic Press, Inc.

STAB6654 Insect Physiology

This course will discuss the internal processes that make it possible for an insect to survive and reproduce. The basic physiological processes in insect include nutrition and digestion, excretion (salt and water balance), respiratory and circulatory system, reproduction, muscle and movement, sensory and nervous systems, as well as exo- and endo-drine systems. Students will also learn about the electrical events in cells, fat content and its metabolisme, integument and molting process, brain and sensory intergration in coordinating physiology and functions. Students will also be exposed to the molecular aspects of egg yolk and chitin development as well as insect resistance to chemical and microbiological insecticides. At the end of the course, students are required to write a term paper of a chosen topic related to insect physiology.

References

Beckage, N.E. 2008. *Insect Imunology.* Amsterdam: Boston, Academic Press.

Blomquist G. J. & Vogt. R. G. 2003. *Insect Pheromone Biochemistry and Molecular Biology*. Amsrerdam: Elsevier Academic Press.

Klowden, M.J. 2007. *Physiological Systems in Insects*. 2nd. Ed. USA: Academic Press.

Nation, J.L. 2002. *Insect Physiology and Biochemistry*. Boca Raton: CRC Press.

Springer Chapman, R.F. 1998. *The Insects Structure and Function.* Cambridge UK: Cambridge University.

STAB6664 Medical and Urban Entomology

This course will discuss the introduction and classification of insect of medical importance (human, domestic and husbandry animals), structural insect pests as well as those infesting

food, stored products and other materials. Students will also be exposed to biological, ecological and behavioral aspects of medical and urban insect pests, and the latest control approaches (integrated management) especially using methods and strategies that are environmental friendly, easy to be used, cheap and socially acceptable. In addition, legal aspects and the impact of each control method to the economy and politics will also be discussed. The discussion will focus more on mosquitoes, flies (including *Drosphila melanagaster*), cockroaches, termite, fleas, bedbug, tick and mites. Visit to centres or research institutes related to this course will be conducted to give opportunity to students to relate what is taught in classes with what has been or being done to insects of medical, urban or structural, stored product importance. At the end of the course students are required to prepare a term paper with the topic of their choice related to insects that have been discussed in this course.

References

Eldridge, B.F. & Edman, J.D. 2000. *Medical Entomology: A Rextbook on Public Health and Veterinary Poblems Caused by Arthropods.* Iowa: Kluwer Academic Publication.

Mike, W. 2000. *Medical Entomology for Students Service.* 2nd. Ed. London: Cambridge University Press.

Maramorosch, K. & Mahmood, F. 1999. *Maintenance of Human, Animal and Plant Pathogen Vectors.* New York: Science Publishers Inc.

Olkowski, W., Daar, S. & Olkowski, H. 1993. *Common-sense Pest Control.* Newtown: The Taunton Press.

Walter, E. 1975. *Urban Entomology.* Los Angeles: University of California Publ.

STAB6673 Molecular Entomology

Molecular entomology will give the opportunity to students to keep abreast with current trend of using molecular biology tools to comprehend better understanding about insects. Students will be exposed to techniques of how to manipulate insect for disease control both on human and crops as well to improve integrated insect pest management programme. As such, this course will initially introduce students with a basic knowledge of molecular biology of insects and other eucaryotic organisms followed by how to apply the molecular technologies and biotechnologies to entomological topics including molecular genetic of insect behavior, systematics and evolution, transfection of plant with insecticidal genes, transgenic insect, improving virulence of biological control and molecular mechanism of pesticides resistant. Analysis of molecular processes unique to insects, and their potentials for genetic engineering will also be taught. This course will exclusively be taught by lectures and discussions. Students will also have the opportunity to visit a molecular biology laboratory to exchange views with other molecular biology students and they use molecular biology tools in their work.

References

Hill, D.M. & Mable, B.K. 1996. *Molecular Systematics*. 2nd. Ed. Sinauer Associates, Inc. Sunderland, MT, USA.

Hoy, M.A. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications.* 2nd. Ed. New York: Academic Press.

Marshall, G. & D. Walters. 1994. *Molecular Biology in Crop Protection*. London: Chapman & Hall.

Romoser, W.S. & Stoffolano, J.G. 1998. *The Science of Entomology.* Boston: WCB McGraw-Hill.

Wiley, E.O. 1991. *Phylogenetics: The Theory & Practices of Phylogentic Systematics*. John Wiley & Sons Inc., N.Y.

MASTER OF SCIENCE
(MANAGEMENT OF PLANT GENETIC RESOURCES)

Introduction

This programme is carried out as an international level programme with cooperation from the International Plant Genetic Resources Institute (IPGRI), with the aim of providing theoretical expertise and pertinent practicals required for the sustainable management of plant genetic resources. Educational expertise of Universiti Kebangsaan Malaysia will be complemented by the vast experience of leading national research institutions such as Forest Research Institute Malaysia (FRIM), Malaysian Palm Oil Board (MPOB), Malaysian Agricultural Research and Development Institute (MARDI), Malaysian Institute for Nuclear Technology Research (MINT), and Malaysian Rubber Board (MRB), and their experienced staff will provide the relevant inputs in conducting this course. The strong collaborative element between the universities and the national research institutions will bring in flexibility and practicality in the approach to training, and consequently will ensure the success and also increase the relevance of the training.

Entry Requirements

Prospective candidates should possess a good first degree in Biological Sciences (or the equivalent in biology, genetics, plant breeding, horticulture, plant breeding, agronomy or agriculture). Candidates well qualified in any other related field may also be considered, provided they have had experiences considered relevant to this field of study.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce a graduate who has mastered the plant genetic resource management knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To develop effective communication skills of national and international standings.

PROGRAMME LEARNING OUTCOME (PO)

PO1: Master the basic knowledge in plant genetic resources, their conservation, use and management, and related disciplines.
PO2: Able to apply theoretical expertise and strategies for plant genetic resources for their conservation to utilization.
PO3: Able to identify problems in management of plant genetic resources and solve the problems effectively.
PO4: Able to undertake a plant genetic resources related works effectively as an individual and in teams.
PO5: Able to communicate effectively verbally and in writing with the scientific community and the public in addressing local and global issues related with plant genetic resources.
PO6: Are competent in using current literature and appropriate research methodologies, and contribute new information to management of plant genetic resources.
PO7: Able to understand in-depth different plant genetic resources, diversity, importance, impacts and their use.
PO8: Understand problems and use best practices in the management of plant genetic resources.

PO9: Acquire knowledge and skills in entrepreneurship and management to develop and commercialize research findings.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 unit hours, comprising 23 credit hours of core courses and 17 credit hours of elective courses. Candidates are encouraged to expand their individual interests through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSES	TOTAL
I	STPD6014 Research Methodology STAP6073 Environmental Management System STAP6043 Plant Diversity and Systematics STAP6974 Research Project I	STAB6903 Diversity of Plant Genetic Resources STAB6924 Advanced Plant Biotechnology	**21**
II	STAP6033 Biogeography STAP6986 Research Project II	STAB6013 Conservation Biology STAB6143 Economic Botany and Ethnobotany STAB6914 Plant Breeding	**19**
	23	**17**	**40**

Courses Offered

STPD6014 Research Methodology
STAP6043 Plant Diversity and Systematic
STAP6073 Environmental Management System
STAP6974 Research Project I
STAP6986 Research Project II
STAB6013 Conservation Biology
STAB6143 Economic Botany and Ethnobotany
STAB6903 Diversity of Plant Genetic Resources
STAB6914 Plant Breeding
STAB6924 Advanced Plant Biotechnology
STAB6033 Biogeography

Course Contents

STAB6013 Conservation Biology

The Earth is now in a critical period for the survival of its natural ecosystems and their plant and animal members. Conservation biology is a multidisciplinary science that has been

developed to deal with this crisis. Conservation biology is not just about maintaining viable populations of all species. Conservation is also about moral philosophy, social justice, economics and politics. The course will be divided into a number of sections to reflect this multidisciplinary approach, namely the origins of conservation biology; biological diversity and its importance; threats to biological diversity; protection, restoration and management of populations, species, habitats and ecosystems; and economics and sustainable development.

References

Dyke, F.V. 2008. *Conservation Biology: Foundations, Concepts, Applications*. Holland: Springer.

Groom, M.J. Meffe, G.K. & Carroll, C.R. 2005. *Principles of Conservation Biology*. 3rd. Ed. USA: Sinaues Associates.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosembaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., Soehartono, T., Stanley, S. & O'Brien, T. 2005. *Life After Logging: Reconciling Wildlife Conservation and Production Forestry in Indonesian Borneo.* Jakarta: CIFOR & UNESCO.

Primack, R.B. 2006. *Essentials of Conservation Biology*. 4th. Ed. New York: Sinauer.

Sodhi, N.S. & Brook, B.W. 2005. *Southeast Asian Biodiversity in Crisis.* Cambridge: University Press.

STAB6143 Economic Botany and Ethnobotany

The course will focus and discuss the plant botanical aspects that have economic and ethnobotanical importance to man including their role in culture and civilization of man. It also covers some plant commodity groups such as food crops (rice and other carbohydrate sources), medicinal plants and plants in rural and urban landscape. A brief history on the use of plants among the people of Southeast Asia will be outlined from the aspects of biology, environment, socio-economy, culture and their roles in modern utilization such as plantation crops and agro-biotechnology.

References

Ford, R. 1980. *The Nature and Status of Ethnobotany*. New York : University of Michigan.

Martin, J. G. 1994. *Ethnobotany*. London: Chapman & Hall.

Mat-Salleh, K. & A. Latiff. 2002. *Tumbuhan Ubatan Malaysia. Bangi : Pusat Pengurusan Penyelidikan*. Universiti Kebangsaan Malaysia.

Purseglove, J. W. 1972. *Tropical Crops: Dicotyledons and Monocotyledons*. Harlow : Longmans.

Zakri, A. H. 1989. *Genetic Resources of Under-Utilised Plants in Malaysia.* Kuala Lumpur: Malaysian National Committee for Plant Genetic Resources.

STAB6903 Diversity of Plant Genetic Resources

The course covers various topics on plant diversity, with emphasis on different plant species that are used for food and agriculture, and for other uses such as animal feed, fibers, industrial biomaterials and medicine. Diversity between and within plant species for major, minor and underutilized crops will be discussed. Important aspects include general principles of diversity and evolution, origins of agriculture and domestication, centre of origin and diversity, history of distribution, gene pools, breeding systems, cytogenetically variation, introgression, genetic vulnerability and erosion, interdependence between countries, value of plant diversity, land races and their wild and weedy progenitors, and their use in breeding modern varieties. Examples include plantation crops, cereals, oil crops, fruit trees, root and tuber crops, grain legumes, vegetables, beverages, spices, medicinal and aromatic plants. The course also covers the history of plant germplasm collecting, legal issues in plant germplasm collecting and conservation. Includes field visits.

References

FAO. 1996. The State of the World's Plant Genetic Resources for Food and Agriculture. Background documentation for the International Technical Conference on Plant Genetic Resources, Leipzig, Germany. Available online as a pdf file.

Guarino, L, Ramanatha Rao, V. & Reid, R. (Eds). 1995. *Collecting Plant Genetic Diversity.* U.K: CAB International,

Hoelzel, A. R. (Ed). 1998. *Molecular Genetic Analysis of Populations. A Practical Approach.* 2nd. Ed. Oxford: Oxford University Press.

Holden, J. H. W., Peacock, J. & Williams, J. T. 1993. *Gene, Crops and the Environments.* Cambridge: University Press.

Smart, J. & Simmonds, N. W. 1994. *Evolution of Crop Plants*. 2nd. Ed. London: Longman.

STAB6914 Plant Breeding

The course covers both crop improvement and tree breeding. Topics on crop improvement include genetic principles in breeding and improvement of crop plants, plant genetic resources, breeding systems, host-pathogen interactions, genetics of resistance and pathogenicity, monogenic and polygenic inheritance, heritabilities, heterosis, ideotypes, hybridization and selection, mass selection, pedigree selection, backcrossing, inbreeding, hybrid varieties, resistance against pests and diseases, genotype x environment interactions, and applied cytogenetics, physiological breeding, gene manipulation and genetic engineering in relation to their use in plant breeding. Topics on tree breeding include genetic principles in breeding and improvement of forest species in relation to production forestry, tree improvement strategies, selection methods, seed production area, seed orchards, genetic testing programmes, reproductive biology and advances in propagation technology, hybrids in tree improvement, wood and tree improvement, advanced generation selection, gains and economics of tree improvement, and applications of biotechnology in tree improvement. The course also covers population and quantitative genetics which are closely related to plant breeding. Includes field visits.

References

Chahal, G. S. & Gosal, S. S. 2002. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches.* CRC Press & Narosa Publishing House.

Falconer, D. S. & MacKay, T. F. C. 1997. *Introduction to Quantitative Genetics*. London: Longman Group Ltd.

Poehlman, J. M. & Sleper, D. A. 1996. *Breeding Field Crops*. 4th. Ed. Ames: Iowa State University Press.

Simmonds, N. M. 1979. *Principles of Crop Improvement*. London: Longman.

Wood, D. R. (ed.) 1983. *Madison: Crop Breeding*. ASA?CSSA.

Zobel, B. & Talbert, J. 1984. *Applied Forest Tree Improvement*. New York: John Wiley and Sons.

STAB6924 Advanced Plant Biotechnology

The course gives an introduction and overview of important biotechnologies and explores the ways in which new biotechnologies can contribute and be applied to crop improvement or tree breeding programmes. The biotechnologies include genomics and bioinformatics, mapping plant genomes with molecular markers, transformation systems, analysis of transgenic plants and application of plant genetic manipulation. Practical classes given are primarily associated with the current genomic tools and genetic manipulation techniques used in crop and tree improvement. Includes visits to biotechnology laboratories.

References

Baxevanis A.D. & Ouellette, B.F.F.2001. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. New York, USA: John Wiley & Sons, Inc.
Lewin, B. 2000. *Genes VII*. New York: Oxford University Press Inc.
Liu, B. 2000. *Statistical Genomics: Linkage, Mapping and QTL Analysis.* N.W.: Corporate Blvd.

MASTER OF SCIENCE (PLANT SYSTEMATICS)

Introduction

Systematic botany is an important component in life sciences, dealing primarily on a science of arranging plants into natural groupings and the naming of these groups. Systematic principles aim to produce classification systems which best express the various degrees of overall similarity between the living organisms. Such systems are used in biology for the storage, retrieval and communication of information and for the making of reliable predictions and generalizations. They are based on as broad as possible study of the variation of living organisms and aim to establish groups, the members of which possess the largest number of common features and exhibit therefore the greatest overall similarity. This expertise will provide a basic service to biology, especially on identity, probable close relatives and characteristics of plants to those who require it, especially to those doing research in other areas of biology. Plant systematic will be able to provide an accurate name, expressing natural relationships. This will support other life sciences such as plant biotechnology, pharmaceutical, forestry, agriculture and environmental sciences.

This program aims to help enhance the expertise of our biologists with knowledge and basic expertise to be involved in systematic and taxonomic projects. This will contribute to the capacity building in this area especially in megadiversity countries of the tropics. It will also complement other interests such as ecology, system management, agriculture, environmental and development assessment, plant genetic resource management, natural resource exploration, environmental education. This one year course provides a stimulating approach to a wide range of modern taxonomic theory and practice, especially on taxonomic foundations, biodiversity assessment methodologies, economic and applied aspects such as ethnobotany, economic botany, natural resources and conservation, bioprospecting and Flora writing. It is therefore attractive not only to those intending to follow plant taxonomy or systematic professionally, but also to those with interests in such areas as ethnobiology, plant ecology, dendrology, management of genetic resources, biodiversity and conservation biology.

Entry Requirements

Applicants should have a good degree in appropriate sciences:

a) A good degree of BSc Honours in Biology, Life Sciences, Forestry, or related fields that is approved by the UKM Senat, or
b) Other equivalent degree other than Biology, Life Sciences or Forestry, or related fields, and other qualification or related experience that is approved by the UKM Senat.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce a graduate who has mastered the plant systematic knowledge holistically.
PEO2: To produce a graduate who has competence in soft skills.
PEO3: To produce a graduate who has the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.

PEO5: To develop effective communication skills of national and international standings.

PROGRAMME OUTCOME (PO)

PO1: Able to state, define, and give examples of the components of taxonomy: description, identification, nomenclature, and classification.
PO2: Able to describe a plant using the descriptive terminology of plant morphology, anatomy, embryology, palynology, molecular and reproductive biology.
PO3: Able to draw cladograms of the major lineages of plants, indicating their classification, major evolutionary events, and adaptive significance of those evolutionary changes.
PO4: Able to name, classify, and diagnose the major families of vascular plants.
PO5: Able to collect (including properly recording field data), identify, and process a plant for herbarium specimens.
PO6: Able to state the principles and rules of plant nomenclature, such as how to publish a new taxon name, and how to use and apply botanical names.
PO7: Able to understand the basics of the theory and methodology of phylogenetic systematics and how it is applied in research.
PO8: Able to design and undertake a project in plant systematic research.
PO9: Able to use the major literature sources in plant systematics, including bibliographic surveys.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 unit hours, comprising 20 credit hours of core courses and 20 credits of elective courses and 10 credit hours of research. Candidates are encouraged to expand their individual interests through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSES	TOTAL
I	STPD6014 Research Methology STAP6043 Plant Systematics and Diversity STAP6974 Research Project I	STAB6174 Principle and Methods of Phylogeny Reconstruction STAB6123 Taxonomic Data and Resource Management STAB6153 Plant Micromorphology and Anatomy	**21**
II	STAB6143 Economic Botany and Ethnobotany STAP6986 Research Project II	STAB6013 Conservation Biology STAP6033 Biogeography STAB6134 Phylogeny, Diversity and Taxonomy of Cryptograms	**19**
TOTAL	**20**	**20**	**40**

Courses Offered

STPD6014	Research Methodology
STAP6033	Biogeography
STAP6043	Plant Systematic and Diversity
STAP6974	Research Project I
STAP6986	Research Project II
STAB6013	Conservation Biology
STAB6123	Taxonomic Data and Resource Management
STAB6134	Phylogeny, Diversity and Taxonomy of Cryptograms
STAB6143	Economic Botany and Ethnobotany
STAB6153	Plant Micromorphology and Anatomy
STAB6174	Principles and Methods of Phylogeny Reconstruction

Course Contents

STAB6013 Conservation Biology

The Earth is now in a critical period for the survival of its natural ecosystems and their plant and animal members. Conservation biology is a multidisciplinary science that has been developed to deal with this crisis. Conservation biology is not just about maintaining viable populations of all species. Conservation is also about moral philosophy, social justice, economics and politics. The course will be divided into a number of sections to reflect this multidisciplinary approach, namely the origins of conservation biology; biological diversity and its importance; threats to biological diversity; protection, restoration and management of populations, species, habitats and ecosystems; and economics and sustainable development.

References

Dyke, F.V. 2008. *Conservation Biology: Foundations, Concepts, Applications*. Holland: Springer.

Groom, M.J. Meffe, G.K. & Carroll, C.R. 2005. *Principles of Conservation Biology*. 3rd. Ed. USA: Sinaues Associates.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosembaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., Soehartono, T., Stanley, S. & O'Brien, T. 2005. *Life After Logging: Reconciling Wildlife Conservation And Production Forestry in Indonesian Borneo.* Jakarta: CIFOR & UNESCO.

Primack, R.B. 2006. *Essentials of Conservation Biology*. 4th. Ed. New York: Sinauer.

Sodhi, N.S. & Brook, B.W. 2005. *Southeast Asian Biodiversity in Crisis.* Cambridge: University Press.

STAB6123 Taxonomic Data and Resource Management

This course introduces students to the latest method in taxonomic data and resource management. It includes information and documentation system which are important aspects of biological diversity information management. Students are introduced to concepts and principles of database, information system, collection and editing. Students will be exposed to various computer software (Microsoft, GIS, etc.) and will be able to design database management system.

References

Brooks, H.P.C., Phillip, G.J. & Michael, L.J. 1982. *Information Systems Design.* London: Prentice-Hall.

Oxborrow, E. 1989. *Databases and Database Systems.* New York: Chartwell-Bratt.

Reynolds, J. & Busby, J. 1996. *Guide To Information Management in The Context of The Convention on Biological Diversity.* Nairobi: UNEP-World Conservation Monitoring Centre.

Wiederhold, G. 1983. *Database Design.* New York: McGraw-Hill.

Zakri, A.H., Mat-Salleh, K., Sumida, S. & Ogino, K. 1999. *Towards establishment of biodiversity information networking in Southeast Asia.* Dlm: The Tokyo International Forum on Conservation and Sustainable Use of Tropical Bioresources. Tokyo: Japan Biodiversity Association.

STAB6134 Phylogeny, Diversity and Taxonomy of Cryptograms

The courses focuses on discussion on taxonomy, ecology, phytogeography, reproductive biology, phylogeny, diversity and classification of the lower plants or cryptograms. This will include all three part of cryptogram viz. algae, bryophytes and pteridophytes. Practicals involve collection method, curation of specimen, sectioning and preparation of slide and identification of the major groups of cryptogams will be given. Mini project will be given for knowledge enhancement and application of knowledge.

References

Bates, J.W. & Farmer, A.M. (eds.). 1992. *Bryophytes and Lichens in A Changing Environment.* Oxford: Clarendon Press.

Bidin, A.A. 1985. *Paku Pakis Di sekeliling Kita.* Kuala Lumpur: Dewan Bahasa dan Pustaka.

Schuster, R.M. (ed.). 1984. *New Manual of Bryology.* Nichinan: Hattori Botanical Laboratory.

Shaw, J.A. & Goffinet, B. 2000. *Bryophyte Biology.* Cambridge: Cambridge University Press.

Sze, P. 1986. *The Biology of Algae.* Iowa: Wm. C. Brown.

STAB6153 Plant Micromorphology and Anatomy

This course contents emphasize on the plant biodiversity, leaf micromorphology and anatomy which is includes polen morphology. Leaf anatomical and micromorphological characters and the application of these characters as supporting characters in plant systematic will be discussed. Examples of local and foreign species will be given. Polen morphological characters which are useful in identification of plant species will be discussed, including types, classes and aperture ornamentation. Mini project will be given for knowledge enhancement and application of knowledge.

References

Cutler, D.F., Botha, T. & Stevenson, D.W. 2008. *Applied Plant Anatomy, An Applied Approach*. Blackwell Publishing. Oxford, UK.

Judd, W., Campbell, C., Kellog, E. A., Stevens, P. F. & Donoghue, M. J. 2002. *Plant Systematics; A Phylogenetic Approach.* 2nd. Ed. Sinaeur Associates, Inc. Publisher, Sunderland, Masschusetts, United State of America.

Metcalfe, C. R. & Chalk, L. 1950. *Anatomy of The Dicotyledons.* Vol I & II. Oxford: Clarendon Press.

Nilsson, S. & J. Praglowski (eds.). 1992. *Erdtman's Handbook of Palynology*. 2nd. Ed. Copenhagen: Munksgaad

Simpson, M. G. 2006. *Plant Systematics.* London: Elsevier Academic Press.

STAB6174 Principles and Methods in Phylogeny Reconstruction

This course discusses the use of molecular data in plant/animal systematics. Various types of molecular data and multiple sequence alignment of molecular data are explained. The

phylogenetic concepts are approached through the application of various phylogeny reconstruction methods i.e. Neighbour-Joining, Maximum Parsimony and Maximum Likelihood. Students will be exposed to computer software such as BIOEDIT and PAUP for phylogenetic analyses.

References

DeSalle, R., Giribet, G. & Wheeler, W. 2002. *Molecular Systematics and Evolution: Theory and Practice.* Birkhäuser, Basel.

Higgs, P. & Attwood, T.K. 2005. *Bioinformatics and Molecular Evolution*. Blackwell Publishing.

Kitching, I.J., Forey, P.L., Humphries, C.J. & Williams, D.M. 1998. *Cladistics - The Theory And Practice Of Parsimony Analysis*. 2nd. Ed. Oxford-New York-Tokyo: Oxford University Press.

Nei, M. & Kumar, S. 2000. *Molecular Evolution and Phylogenetics*. Oxford University Press.

Yang, Z. 2006. *Computational Molecular Evolution.* Oxford University Press.

MASTER OF SCIENCE (ENGINEERING AND ENVIRONMENTAL GEOPHYSICS)

Introduction

The development in technology for in situ tests have been very rapid for the last two decades especially in the field of civil engineering and environmental industries. Many testing methods and material characterization have been introduced which include the geophysical engineering and environmental techniques. The effectiveness, accuracy and fast as well as relatively low operational cost have made geophysical techniques become important tools in engineering site investigations and in environmental monitoring works. There are various geophysical techniques that can be used to obtain many engineering parameters of material below surface and this field requires skilled and experienced geophysicists to interpret geophysical data collected from the field.

This programme is designed to provide students with specialist training into all aspects of Applied Geophysics, from the basic physical principles through practical applications to state of the art technical geophysical innovations. The main thrust of the course is towards Engineering and Environmental Geophysics industries. The broad-based approach allows graduates to pursue their career options including consulting, research and teaching as well as to prepare themselves for further studies at higher levels. It is also targeted at working professionals wishing to update their knowledge or acquire new skills in the field of engineering and environmental geophysics.

Entry Requirements

a) Candidates should possess a Bachelors degree in Science with a good CGPA from Universiti Kebangsaan Malaysia or from other universities approved by the Senate, or
b) Possess other qualification equivalent to a Bachelor of Science degree but must have at least a few years working experience in fields related to Geophysics which is approved by the Senate.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

PEO1: To produce a graduate who has mastered the current engineering and environmental geophysical knowledge holistically.

PEO2: To produce a graduate who has competence in soft skills.

PEO3: To produce a graduate who is the awareness towards environment.
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development.
PEO5: To produce a graduate who was able to use Bahasa Melayu in order to give impetus to the national and global development.

PROGRAMME LEARNING OUTCOME (PO)

PO1: Mastery in engineering and environmental geophysical knowledge which can contribute to other disciplines.
PO2: Having in-depth technical competence in engineering and environmental geophysics and able to undertake problem identification, formulation and solution.
PO3: Be able to apply and disseminate engineering and environmental geophysical knowledge effectively.
PO4: Competence to conduct research & development in engineering and environmental geophysical and possess high creativity and innovative skills.
PO5: Possess moral, ethical and professional values and environmentally concern.
PO6: Capable to work skillfully and communicate effectively.
PO7: Possess entrepreneurship and leadership skills effectively.
PO8: Willingness to to explore and adopt long life learning.
PO9: Possess high confidence, self-esteem and open minded.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 unit hours, comprising 19 credit hours of core courses and 21 credit hours of elective courses. Candidates are encouraged to expand their individual interests through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSE	TOTAL
I	STPD6014 Research Methodology STAP6073 Environmental Management System STAP6974 Research Project I	STAG6314 Engineering Geophysics STAG6324 Environmental Geophysics STAG6334 Instrumentation and Field Geophysics	**23**
II	STAP6092 Environment Ethics STAP6986 Research Project II	STAG6343 Geophysical Data Processing STAG6353 Geophysical Data Interpretation STAG6363 Hydrogeology and Contaminant Process	**17**
TOTAL	**19**	**21**	**40**

Courses Offered

STPD6014	Research Methodology
STAP6073	Environmental Management System
STAP6092	Environment Ethics
STAP6974	Research Project I
STAP6986	Research Project II
STAG6314	Engineering Geophysics
STAG6324	Environmental Geophysics
STAG6334	Instrumentation and Field Geophysics
STAG6343	Geophysical Data Processing
STAG6353	Geophysical Data Interpretation
STAG6363	Hydrogeology and contaminant process

Course Contents

STAG6314 Engineering Geophysics

This course discusses basic principles of geophysical methods that are used in site investigation to obtain subsurface engineering information. Emphasis will be given to latest geophysical techniques (surface and subsurface) used in the industry. The relationship between geophysical parameters and engineering geological properties of rock and soil will be discussed together with some case studies.

References

Burger, H.R. 1992. *Exploration Geophysics of The Shallow Subsurface, W/Macintosh Computer Software.* New Jersey: Prentice Hall.

Griffiths, D.H. & King, R.F. 1981. *Applied Geophysics for Geologists and Engineers.* 2nd. Ed. New York: Pergamon Press.

Karous, M., Kelly, W.E. & Mares, S. (pnyt.). 1993. *Applied Geophysics in Hydrogeological and Engineering Practice.* London: Elsevier Science.

Sharma, P.V. 1997. *Environmental and Engineering Geophysics.* Cambridge: Cambridge University Press.

Telford, W.M., Geldart, L.P. & Sheriff, R.E. 1990. *Applied Geophysics.* 2nd. Ed. Cambridge: Cambridge University Press.

STAG6324 Environmental Geophysics

This is an introduction course to theory and application of geophysical methods (Geoelectrical resistivity, seismic, magnetic, gravity, induced polarization, self potential, electromagnetic and ground penetration radar) for environmental evaluation of development sites. Special emphasis on waste disposal and contaminated sites, detection and mapping of sinkholes and shallow buried objects as well as case studies will be given.

References

Burger, H. R. 1992. *Exploration Geophysics of the Shallow Subsurface, W/ Macintosh Computer Software.* New Jersey:Prentice Hall.

Karous, M. Kelly, W.E. & Mares, S.(pnyt), 1993. *Applied Geophysics in Hydrogeological and Engineering Practice.* London: Elsevier Science.

Reynolds, J.M. 1997. *An Introduction to Applied and Environmental Geophysics.* New York: John Wiley & Sons.

Sharma, P. V. 1997. *Environmental and Engineering Geophysics*. Cambridge: Cambridge University Press.

Telford,W.M.,Geldart, L.P. & Sheriff, R.E. 1990. *Applied Geophysics.* 2nd. Ed. Cambridge: Cambridge University Press.

STAG6334 Instrumental and Field Geophysics

This course will discuss the working principle of various geophysical instruments and develop skills of students to operate the equipment for quality geophysical field data collection and a full understanding of the limitations of each instrument in use.

References

Burger, H. R. 1992. *Exploration Geophysics of The Shallow Subsurface.w/ Macintosh Computer Software.* New Jersey: Prentice Hall.

Milson, J. 2003. *Field Geophysics.* 3rd. Ed. London: John Wiley & Sons.

Robinson, E. S. & Coruh, C. 1988. *Basic Exploration Geophysics.* London: John Wiley.

Reynolds, J.M. 1997. *An Introduction to Applied and Environmental Geophysics*. London: John Wiley & Sons.

Telford,W.M., Geldart, L.P. & Sheriff, R.E. 1990. *Applied Geophysics* 2nd. Ed. Cambridge: Cambridge University Press.

STAG6343 Geophysical Data Processing

This course covers the basic principles of methods used in analyzing digital signal for geophysical applications. The topics include basic understanding of classification and representation of signals and systems, linear system, analysis and Fourier system, continuous and discrete signals, filtering, modulation, sampling theory, phase properties of digital signal and filtering. Regression: linear, least square and non linear regression and robust estimation will also be discussed.

References

Bracewell R. 1978. *The Fourier Transform and Its Application*. New York: Mc. Graw Hill.

Claerbout, J.F. 1976. *Faundamentals of Geophysical Data Processing With Applications To Petroleum Prospecting*. New York: Mc Graw Hill Book Co.

Haykin, S & Vun Veen, B. 1999. *Signal and Systems.* New York: John Wiley

Kamen, E.W. & Heck, B.S. 2000. *Fundamentals of Signals and Systems.* New Jersey: Prentice Hall.

Oppenheim, A.V. & Schafer, R.W. 1975. *Digital Signal Processing.* New Jersey: Prentice Hall.

Robinson, E.A. & Sven Treitel. 1980. *Geophysical Analysis*. New Jersey: Prentice Hall Inc.

Robinson, E.A 1978. *Digital Signal Processing and Time Series Analysis.* Holden-Bay.

STAP6353 Geophysical Data Interpretation

This course covers the basic principles of engineering and environmental geophysical data interpretation. Emphasis will be given to digital surface and subsurface geophysical data used in the industry and the application of computer software for data interpretation, results presentation (reports, graphic and maps) and communication as well as to build up the student ability to relate results and local geology.

References

Burger, H.R. 1992. *Exploration Geophysics of the Shallow Subsurface, W/ Macintosh Computer Software.* New Jersey: Prentice Hall.

Reynolds, J.M. 1997. *An Introduction to Applied and Environmental Geophysics.* New York: John Wiley & Sons.
Sharma, P.V. 1997. *Environmental and Engineering Geophysics*. Cambridge: Cambridge University Press.
Telford, W.M., Geldart, L.P. & Sheriff, R.E. 1990. *Applied Geophysics.* 2nd. Ed. Cambridge: Cambridge University Press.
Ward, S.H. 1992. *Geotechnical and Enviromental Geophysics.* Tulsa: Soc. of Expl. Geophysics.

STAG6363 Hydrogeology and Contamination Process

This course focuses on the basic theory of ground water flow and geological control which also covers evaluation, application and characterization of water resources. Understanding the inorganic chemistry and organic compounds in ground water, multiphase movement, transformation, retardation and attenuation of contaminants and other related geological processes will also be discussed.

References

Domenico, P.A. & Schwartz, F. 1997. *Physical and Chemical Hydrogeology.* New York: John Wiley & Sons.
Fetter, C.W. 1998. *Contaminant Hydrogeology.* 2nd. Ed. New York: Pearson Education.
Sen, Z. 1995. *Applied Hydrogeology for Scientist and Engineers.* Istanbul: Technical University, Turkey.
Weight, W.D. & Sonderegger, J.L. 2001. *Manual of Applied Field Hydrogeology.* London: McGraw-Hill.

MASTER OF SCIENCE (ENGINEERING GEOLOGY)

Introduction

The development of a nation involves the construction of infrastructure such as dams, highways, industrial complexes, ports and airports. Such construction involves the interaction between earth materials and masses with the constructed structures. Characterization of earth materials and masses plays an important role in influencing the usage, safety and economic effectiveness of these constructions. In Malaysia's efforts to attain developed nation status by 2020, such construction activities are expected to increase considerably. At the same time, sites and areas that are less suitable also need to be developed. One important input for conducting safe construction is engineering geological input.

The Master of Science (Engineering Geology) programme aims to further train engineering geologists to recognize and overcome issues that can arise during construction and propose solutions that are safe and economical. This programme will enhance the knowledge of engineering geologists in conducting such investigations and studies at and below the earth's surface.

Entry Requirements

Candidates interested in participating in this programme should have either

a) a Bachelor of Science (Geology) degree with a good CGPA from Universiti Kebangsaan Malaysia or other universities approved by the Senate, or
b) other qualifications equivalent to a Bachelor of Science and working experience in related fields approved by the Senate.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce graduates with engineering geological knowledge that is strong and broad based so that they posses the ability to explore and expand this knowledge.
PEO2: To absorb the basic skills required in developing engineering geological and applied geological knowledge together with related scientific fields.
PEO3: To train students for application of engineering geological knowledge in different use ages.
PEO4: To prepare students for further higher level education such as PhD.
PEO5: To prepare students for a career in research at public and private institutions.
PEO6: To enable FST to become a center of excellence in engineering geology.

PROGRAMME LEARNING OUTCOME (PO)

PO1: Mastery of several aspects of engineering geology and understand its relationship to other science and engineering disciplines
PO2: Have in-depth technical competence in engineering geology and the ability to identify problems and formulate practical solutions.
PO3: Posses the ability to apply and disseminate engineering geological knowledge effectively.
PO4: Posses the competence to conduct research & development in engineering geology and possess high creativity and innovative skills.
PO5: Possess high moral, ethical and professional values and sensitive to social responsibility.
PO6: Posses the ability to work skillfully and communicate effectively.
PO7: Possess effective entrepreneurship and leadership skills.
PO8: Be prepared to explore and adopt long life learning.
PO9: Possess high confidence, self-esteem and be open minded.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 unit hours, comprising 19 credit hours of core courses and 21 credit hours of elective courses. Candidates are encouraged to expand their individual interests through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSE	TOTAL
I	STPD6014 Research Methodology STAP6073 Environmental Management System STAP6974 Research Project I	STAG6213 Engineering Geology STAG6234 Rock Engineering STAG6314 Engineering Geophysics	**23**
II	STAP6092 Environment Ethics STAP6986 Research Project II	STAG6224 Soil Engineering STAG6243 Geohazard Investigation STAG6083 Hydrogeology	**17**

TOTAL	**19**	**21**	**40**

Courses Offered

STPD6014 Research Methodology
STAP6073 Environmental Management System
STAP6092 Environmental Ethics
STAP6974 Research Project I
STAP6986 Research Project II
STAG6083 Hydrogeology
STAG6213 Engineering Geology
STAG6234 Rock Engineering
STAG6224 Soil Engineering
STAG6243 Geohazard Investigation
STAG6314 Engineering Geophysics

Course Contents

STAG6083 Hydrogeology

Definition and scope of hydrogeology. Relationship with fields of science and engineering. Groundwater: occurrence and types. Hydrologic cycle. Concept of porosity and permeability. Water containing layers and their characterization. Darcy's law. Determination of permeability in the laboratory and field. Hydrogeochemistry. Water as a universal solvent. Types of solutions in water. Chemical classification of water. Exploration of groundwater and use as a water source.

References

Domenico, P.A. & Schwartz, F.S. 1997. *Physical and Chemical Hydrogeology*. New York: John Wiley & Sons.
Fetter, C.W. 1998. *Contaminant Hydrogeology*. 2nd. Ed. New York: Pearson Education.
Sen, Z.1995. *Applied Hydrogeology for Scientists and Engineers*. Turkey: Istanbul Technical University.
Weight, W.D. & Sonderegger, J.L. 2001. *Manual of Applied Field Hydrogeology*. London: Mc Graw-Hill.

STAG6213 Engineering Geology

This course commences with a discussion of the introduction, definition, background and development of engineering geology. Classification system for soils and rocks. Engineering geological mapping. Types of engineering geological maps. Map scale and types of construction. Engineering geological mapping in tropical terrains. Planning of engineering geological investigations. Drilling and its logging. Sampling. Test pits and its logging. Soundings and penetration testing. Standard penetration test. Cone penetration test. Interpretation of testing. Reporting of engineering geological investigations.

References

Attewell, P.B. & Farmer, I.W. 1976. *Principles of Engineering Geology*. London: Chapman & Hall.
Bell, F.G. 1980. *Engineering Geology and Geotechnics*. London: Newness-Butterworths.
Goodman, R.E. 1989. *Introduction to Rock Mechanics*. New York: John Wiley & Sons.
Hudson, J.A. (pnyt). 1993. *Comprehensive Rock Engineering*. Jil. 1-5. London: Pergamon Press.
Zaruba, Q. & Mench, V. 1976. *Engineering Geology*. Amsterdam: Elsevier.

STAG6224 Soil Engineering

Flow of ground water, flow nets and their application. Darcy's Law. Consolidation of soils. Shear strength of soils, stress-strain behaviour. Elasticity of soils. Mohr-Coulomb theory. Earth pressure. Retaining walls. Rankine theory. Bearing capacity of soils, foundation of buildings. Site investigation and field testing of soils. Physio-chemistry and mineralogy of soils. Physical and chemical stabilization of soils. Case studies e.g. highways, earth dams, foundations of buildings.

References

Abrahamson, L.W., Lee,T.S., Sharma, S. & Boyce, G.M. 2001. *Slope Stability and Stabilization Methods*. 2nd. Ed. New York: John Wiley & Sons.

Budhu, M. 1999. *Soil Mechanics and Foundations*. New York: John Wiley & Sons.

Das, B.M. 1997. *Advanced Soil Mechanics.* New York: Taylor and Francis Ltd.

Lambe, T.W. & Whitman, R.V. 1979. *Soil Mechanics*. SI Units. New York: John Wiley & Sons.

Terzaghi,K.,Peck,R.B. & Mesri,G. 1996. *Soil Mechanics in Engineering Practice*. 3rd. Ed. New York: John Wiley & Sons.

STAG6234 Rock Engineering

Introduction, background and development of rock mechanics and geomechanics. Geology based rock mechanics. Rock mass classification systems: RMR and Q systems. Inhomogeniety and anisotropy. Role of discontinuities in the mechanical behaviour of rock materials and rock masses. Discontinuity characterization. Rock mechanics inputs for subsurface construction (tunnels, caverns), dams and industrial plants. Practical classes will involve the determination of the physical and mechanical properties of rock materials and rock masses in the laboratory and field, together with problem solving exercises related to rock stability in construction.

References

Brown, E.T. 1981. *Rock Characterization, Testing and Monitoring.* ISRM Suggested Methods. London: Pergamon Press.

Hoek, E. & Brown, E.T. 1980. *Underground Excavation Inrock.* London: London Institution of Mining and Metallurgy.

Hudson, J.A. (Ed.). 1993. *Comprehensive Rock Engineering.* Jil. 1&3. London: Pergamon Press.

Priest, S.D. 1993. *Discontinuity Analysis for Rock Engineering.* New York: Chapman Hall.

Wittke, W. 1990. *Rock Mechanics: Theory and Applications with Case Histories.* Berlin: Springer Verlag.

STAG6243 Geohazard Investigation

This course discusses natural and geological processes that affect the human environment in a catastrophic way. Geohazards are normally magnified by human activities. Classification of geohazards. Concept of hazard and risk. Landslides: definition, identification and classification. Landslide hazard and risk management. Case studies. Subsidence and sinkholes. Earthquakes: classification, magnitude and intensity. Detection and measurement. Earthquake hazard and mitigation. Tsunami: background and characterization. Impact, damage, monitoring, early warning and mitigation. Malaysia's policy and planning response for earthquake and tsunami hazards. Floods. Erosion. Hazard and risk management.

References

Bromhead, E.N. 1994. *The Stability of Slopes.* London: Blackie Academic & Professional.

Bruensden, D. & Prior, D.B. 1973. *Slope Instability.* Chichester: John Wiley & Sons.

Crozier, M.J. 1986. *Landslides: Causes, Consequences and Environment.* London: Croom Helm.

Hoek, E. & Bray, J. 1977. *Rock Slope Engineering. Institution of Mining and Metallurgy.* London: Elsevier Applied Science.

Richards, L.R. & Antherton, D. 1987. *Stability of Slopes in Rocks.* In: Bell, F.G. (pnyt). *Ground Engineers Reference Book.* London: Butterworth Heinemann.

STAG6314 Engineering Geophysics

This course discusses basic principles of geophysical methods that are used in site investigation to obtain subsurface engineering information. Emphasis will be given to latest geophysical techniques (surface and subsurface) used in the industry. Relationship between geophysical parameters and engineering geological properties of rock and soil will be discussed together with some case studies.

References

Burger, H. R. 1992. *Exploration Geophysics of The Shallow Subsurface, W/ Macintosh Computer Software*. New Jersey: Prentice Hall.

Griffiths, D.H. & King, R.F. 1981. *Applied Geophysics for Geologists and Engineers*. 2nd. Ed. New York: Pergamon Press.

Karous,M. Kelly,W.E. & Mares, S.(pnyt.) 1993. *Applied Geophysics in Hydrogeological and Engineering Practice.* London: Elsevier Science.

Sharma, P. V. 1997. *Environmental and Engineering Geophysics.* Cambridge: Cambridge University Press.

Telford,W.M. Geldart, L.P. & Sheriff, R.E. 1990. *Applied Geophysics.* 2nd. Ed. Cambridge: Cambridge University Press.

MASTER OF SCIENCE (INDUSTRIAL MINERALS)

Introduction

Industrial minerals are non-metallic natural resources, exclusive of fossil fuel and water. However, some specific rocks are within the scope of industrial mineral study. Raw industrial minerals can be processed into daily and industrial products. Well-known traditional industrial minerals, among others, are clay minerals as raw material for ceramic manufacturing, silica sand for glass manufacturing, limestone as the main component of cement, asbestos in the manufacturing of roof and ceiling, and not to forget talc as foundation of cosmetic products. In industries, barite is used as drilling mud for petroleum exploration wells, mica as good electrical insulator, and hard minerals such as garnet and zircon are used as grinding materials. In the last few decades, the use of industrial minerals has been extended to advanced fields of studies, such as polymer, composite, and electronic materials. While ordinary rocks are source of aggregate materials, those with attractive colour and pattern are sliced and polished into dimension stones, suitable building material for floor and wall.

In order to locate a mineral deposit and to estimate its reserve, exploration programs utilizing special techniques have to be carried out. The industrial minerals must also be studied to suit international standards. The combination of data on exploration, reserve and characterization will enable judgment whether the deposit is economically exploitable, that is after taking into account the current market price.

Entry Requirements

Prospective candidate for this programme must hold

a) Bachelor of Science degree with a good Cumulative Point Grade Average (CPGA) from Universiti Kebangsaan Malaysia or other universities approved by the University Senate in geology or related fields, such as chemistry, physics, material science, environmental sciences, civil and mining engineering; or
b) Other qualifications which are equivalent to a Bachelor of Science degree and hold other qualification or working experience in the relevant field and approved by the University Senate.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce a graduate with in-depth and up to date knowledge in the field of industrial minerals.
PEO2: To produce a graduate with ability to recognize potential area of industrial minerals, to plan and to conduct exploration.
PEO3: To produce a graduate with expertise in analytical techniques and able to use them in evaluating suitability of an industrial mineral.
PEO4: To produce a graduate knowledgeable in rules and legal aspects of environments in relation to exploitation of industrial minerals.
PEO5: To produce a graduate who is interested and able to be an entrepreneur in industrial minerals.
PEO6: To produce a graduate with interest in life-long learning.

PROGRAMME OUTCOME (PO)

PO1: Mastering knowledge in Earth resources in general and industrial minerals in particular.
PO2: Having in-depth understanding about the geological control of industrial mineral occurrences and able to beneficiate it in exploration.
PO3: Able to plan and conduct an industrial mineral exploration.
PO4: Competence in utilizing appropriate analytical techniques in evaluating the suitability of a mineral deposit according to international standards.
PO5: Having in-depth, up to date knowledge about the uses of industrial minerals in the down stream sector.
PO6: Possess moral, ethical, professional and legal values and legal knowledge in ensuring environmental sustainability with regards to mineral exploration.
PO7: Able to use Geographic Information System (GIS) and remote sensing as value-added tools to facilitate industrial mineral exploration.
PO8: Possess basic knowledge in entrepreneurship and economics of industrial minerals.
PO9: Willingness to explore and adopt long life learning.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 unit hours, comprising 20 credit hours of core courses and 21 credit hours of elective courses. Candidates are encouraged to expand their individual interests through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSE	TOTAL

I	STPD6014 Research Methodology STAP6064 Geographic Information System and Remote Sensing STAP6974 Research Project I	STAG6113 Earth Resources STAG6134 Geology of Industrial Minerals STAG6154 Techniques in Industrial Mineral Exploration	**23**
II	STAP6092 Environmental Ethics STAP6986 Research Project II	STAG6104 Analytical Techniques and Assessment of Industrial Minerals STAG6123 Upstream and Downstream Aspects of Industrial Minerals STAG6143Economics of Industrial Minerals	**18**
TOTAL	**20**	**21**	**41**

Courses Offered

STPD6014 Research Methodology
STAP6064 Geographic Information System and Remote Sensing
STAP6092 Environmental Ethics
STAP6974 Research Project I
STAP6986 Research Project II
STAG6104 Analytical Techniques and Assessment of Industrial Minerals
STAG6113 Earth Resources
STAG6123 Upstream and Downstream Aspects of Industrial Minerals
STAG6134 Geology of Industrial Minerals
STAG6143 Economics of Industrial Minerals
STAG6154 Techniques in Industrial Mineral Exploration

Course Contents

STAG6104 Analytical Techniques and Assessment of Industrial Minerals

This introductory subject exposes the students to techniques used in determination of physical properties of materials, such as colour, optical properties, density, porosity, grain size distribution, surface area, liquid limit and plastic limit, compressive strength and abrasion strength; techniques used to generate chemical data of materials using various instruments, such as AAS, XRF, CHNS, XRD, SEM, TEM and wet chemical techniques; and assessment of suitability of materials based on international standards as well as Malaysia standards (SIRIM). This subject involves practical classes.

References

Brown, E.T. 1981. *Rock Characterization, Testing and Monitoring: ISRM Suggested Methods.* London: Pergamon Press.

Collis, L. & Fox, R.A. 1985. *Aggregates: Sand, Gravel, Crushed Rock Aggregates For Construction Purposes.* London: Geol. Soc. London.

Gill, R. 1997. *Modern Analytical Geochemistry*. Essex: Longman.

Moore, D. M. & Reynolds, R.C. 1996. *X-ray Diffraction and The Identification and Analyses of Clay Minerals.* London: Oxford University Press.

Riddle, C. 1993. *Analysis of Geological Materials.* New York: Marcel Dekker Inc.

STAG6113 Earth Resources

This course aims at giving a comprehensive picture of the earth resources, including those that are not traditionally classified as industrial minerals. Topics discussed are type of resource, history of its finds, its importance in human civilization, its distribution and reserve in Malaysia and the world, and its market trend. Among the resources discussed are ground water, metallic and semi-metallic minerals; precious metals such as gold, silver and platinum; energy resource minerals i.e. coal, natural gas, crude petroleum, radioactive minerals and geothermal energy, and industrial minerals such as silica, limestone, clay, aggregate materials and dimension stone. At the end of the course students are expected to outline a scientific and strategic plan on how to benefit a selected resource using an environmentally balanced approach and present it in a seminar.

References

Chiras, D.D. 2001. *Environmental Science*. Sudbury: Jones & Bartlett Publs.

Dietrich, R.V. & Skinner, B.J. 1990. *Gems, Granite and Gravels: Knowing and Using Rocks and Minerals*. New York: Cambridge University Press.

Salley, R.C. 1997. *Elements of Petroleum Geology*. London: Academic Press.

Thomas, L. 2002. *Coal Geology*. New York: John Wiley & Sons. Inc.

Vanecek, M. 1994. *Mineral Deposits of The World: Ores, Industrial Minerals and Rocks* (Development in Economic Geology, Vol.28). Amsterdam: Elsevier.

STAG6123 Upstream and Downstream Aspects of Industrial Minerals

Through this subject students will be introduced into the actual uses of various industrial minerals in downstream sectors (production) and their possible future uses, and principles of mineral processing. This subject includes visits to processing and production plants. Students will also be introduced into the environmental impacts of exploitation of industrial mineral and ways to overcome or to minimize these impacts, as well as safety and legal aspects.

References

Auty, R.M. & Mikesell, R.F. 1999. *Sustainable Development in Mineral Economics*. London: Oxford University Press.

Ciullo, P.A. 1996. *Industrial Minerals and Their Uses*. New York: Noyes Publ.

Kuzvart, M. 1984. *Industrial Minerals and Rocks* (Development in Economic Geology, Vol. 18). Amsterdam: Elsevier.

Wills, B.A. 1997. *Mineral Processing Technologies: An Introduction to The Practical Aspects of Ore Treatment and Mineral Recovery*. 6th Ed. New York: Butterworth-Heinemann.

World Bank. 1992. *Development and the Environment*. Washington D.C.: World Bank.

STAG6134 Geology of Industrial Minerals

The course introduces the students to the geology of various industrial minerals and earth resources required by various industries. The geological aspects aims at looking into the geological characteristics, genesis, distribution in space and time of the industrial mineral and metallic deposits. Topics discussed are the geology of industrial minerals deposits, metallic minerals and energy resources. Case studies are based on local, regional as well as global examples. The course also includes fieldwork to expose students to activities in geology and industrial mineral exploitation.

References

Bates, R.L. 1960. *Geology of The Industrial Rocks and Mineral*. New York: Harper.

Carr, D.D. 1994. *Industrial Minerals and Rocks*. New York: Soc. For Mining, Metallurgy and Exploration.

Lefond, S.J. 1975. *Industrial Minerals and Rocks*. New York: Amer. Inst. of Mining, Metallurgical and Petroleum Engineers.
Manning, D.A.C. 1995. *Introduction to Industrial Minerals*. London: Chapman & Hall.
Vanecek, M. 1994. *Mineral Deposits of The World: Ores, Industrial Minerals and Rocks* (Development in Economic Geology, Vol.28). Amsterdam: Elsevier.

STAG6154 Techniques in Industrial Mineral Exploration

This subject introduces techniques in mineral exploration, including specific mapping technique; shallow geophysical techniques, comprising reflection and refraction seismic techniques, resistivity, magnetic and conductivity; geochemical exploration techniques; and drilling techniques. Students will also be exposed to statistical aspects of sampling and resources, as well as reserve. The subject requires laboratory work and fieldwork.

References

Annels, A.E. 1992. *Mineral Deposit Evaluation*. London: Chapman and Hall.
Keary, P. & Brooks, M . 1984. *Introduction to the geophysical exploration*. London: Blackwell Scientific.
Milsom, J. 1996. *Field Geophysic*. 2nd Ed. New York: John Wiley & Sons - Open Univesity Press.
Ramani, R.V., Muzumdar, B.K. & Samaddar, A.B. 1994. *Computers in Mineral Industry*. London: Ashgate Publishing Company.
Reedman, A.J. 1979. *Techniques in Mineral Exploration*. New York: Applied Scence.

MASTER OF SCIENCE (ENVIRONMENTAL ASSESSMENT AND MONITORING)

Introduction

Preservation of the environmental quality is one of the aspects of development that is considered important in Malaysia based on the Langkawi Declaration 1989 and the United Nations Conference on Environment and Development (UNCED) in Rio De Janeiro, Brazil, 1992. The Environmental Quality Act 1974 further emphasises on the sustainable development to be adopted in any development program in the country.

The Master of Science in Environmental Assessment and Monitoring programme is conducted by coursework within a two semester period. The main objective of the programme is to produce competent and skilled manpower in the field of environmental assessment and monitoring due to rapid development in the country, such as the oil and gas sector and also the infrastructural and other related development in the country.

The number of credits required for the master's degree is 40. The apportionment of these credits is as follows: 13 credit hours in major field (courses offered by the Faculty and School); 17 credits in minor field. 10 credit hours in the major field are to be dissertation research credits. The 40 credit hours must be completed within two semesters.

Entry Requirements

Candidates applying for this programme must possess:

a) Bachelors degree in science with a good CGPA from UKM or other universities approved by the Senate; or
b) Qualification that is equivalent to a bachelor degree or has experience and worked in related fields that are approved by the Senate.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce a graduate who has mastered environmental assessment and monitoring knowledge holistically
PEO2: To produce a graduate who has competence in soft skills
PEO3: To produce a graduate who has the awareness towards environment
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development
PEO5: To develop effective communication skills of national and international standings.

PROGRAMME OUTCOME (PO)

PO1: Mastery of basic knowledge in of environmental assessment and monitoring.
PO2: Technical competence of environmental assessment and monitoring with the ability to use scientific methods to design, conduct experiments, analyze and interpret data.
PO3: Ability to identify and solve problems critically, creatively and innovatively in of environmental assessment and monitoring.
PO4: Ability to work effectively as an individual and as a team.
PO5: Ability to communicate verbally and in writing with the scientific community and the public.
PO6: Ability to obtain, manage and use the latest information systematically and effectively.
PO7: High motivation for life-long learning.
PO8: Ability to understand issues and the need for scientific ethics in society pertaining to culture and the environment.
PO9: Basic knowledge in entrepreneurship and management with the aim to develop and commercialize research findings for a sustainable community and environment.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 credit hours, comprising 23 credit hours of core courses and 17 credit hours of elective course. Candidates are encouraged to expand their individual interests through research projects which commence in the first semester and are supervised by UKM academic staff together with experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSE	TOTAL
I	STPD6014 Research Methodology STAP6073 Environmental Management System STAP6064 Geographical Information System and Remote Sensing STAP6974 Research Project I	STAE6303 Procedures and Techniques in EIA STAB6084 Natural Resource and Environmental Economics	**22**
II	STAP6092 Environmental Ethics STAP6986 Research Project II	STAE6323 Assessment and Monitoring of Air and Water	**18**

		Quality STAB6054 Conservation Ethics and Legislation STAE6013 Management of Lake Ecosystems and Wetlands	
TOTAL	**23**	**17**	**40**

Courses Offered

STPD6014 Research Methodology
STAP6064 Geographical Information System and Remote Sensing
STAP6073 Environmental Management System
STAP6092 Environmental Ethics
STAP6974 Research Project I
STAP6986 Research Project II
STAB6054 Conservation Ethics and Legislation
STAB6084 Natural Resource and Environmental Economics
STAE6013 Management of Lake Ecosystems and Wetland
STAE6303 Procedures and Techniques in EIA
STAE6323 Assessment and Monitoring of Air and Water Quality

Course Contents

STAB6054 Conservation Ethics and Legislation

Ethics and law are essential to conservation. The former sets the objective, and the latter the legal basis. This course will briefly introduce by way of background, the basic issues relating to conservation ethics and law. General ethical concerns, the evolution of laws relating to biological resources, habitat and ecosystems, at both global and national levels will be sketched. Various principles and concepts relating to biological conservation will also be discussed, to identify the inherent values (ethics). Institutional roles and functions will be outlined to describe the accountability and responsibility attached in implementing laws for conservation. The relationship between science, ethics and law will also be analysed in brief.

References

Alder, J. & Wilkinson, D. 1999. *Environmental Law and Ethics.* Macmillan. Press Ltd.

Dower, N. 1989. *Ethics and Environmental Responsibility.* Avebury.

LaFollette, H. (ed.). 2000. *The Blackwell Guide to Ethical Theory.* Blackwell Publishers.

Sands, P. 1995. *Principles of International Environmental Law.* Manchester: Manchester Press

Van Heijnsbergen, P. 1997. *International Legal Protection of Wild Fauna and Flora.* IOS Press.

STAB6084 Natural Resource and Environmental Economics

The course discusses the economic principles of natural and environmental resource conservation. Issues in sustainable economy of renewable and non-renewable resources, economic valuation of natural resource goods and environmental functions and their incorporation into a cost benefit analysis of development projects versus conservation will be

given special attention. A discussion on the use of economic and market-based instruments to encourage natural and environmental resource conservation will be provided.

References

Abdul Hamid H. M. I. & Mohd Shahwahid H.O. 2005. *Penilaian Sumber dan Harta Tanah Hutan*. J. Bahru: Penerbit Universiti Teknologi Malaysia.

McNally, Richard & Mohd Shahwahid H.O. 2003. *Environmental Economics: A Practical Guide*. WWFUK

Mohd Shahwahid H.O. & Jamal O. 1999. *Economic Costs to Malaysia*. Dlm. Glover, D. & Jessup, T. (ed.) hlm. 22-50. Bab 3 of Institute of South East Asian Studies (ISEAS) and Economy & Environment Program for Southeast Asia (EEPSEA) book on "Indonesia's Fires and Haze: The Cost of Catastrophe".

Mohd Shahwahid H.O. 1999 (editor). Manual on Economic Valuation of Environmental Goods and Services of Peat Swamp Forests. Malaysian-DANCED Project on Sustainable Managementof Peat Swamp Forests, Peninsular Malaysia

Mohd Shahwahid H.O., Awang Noor A.G., Abdul Rahim N., Zulkifli Y. & Razani U. 1999. Trade-offs on Competing Uses of a Peninsular Malaysian Forested Catchment. *Environment and Development Economics* 4(4):281-314.

STAE6013 Management of Lake Ecosystems and Wetlands

This course will commence with the introduction of lakes and wetland ecosytem. Its uses and ecosystem function based on case studies of Tasik Chini and Putrajaya lake, which have been intensively studied and researched. The management of both lakes as natural and manmade in terms of lake ecosystems and as a wetland will be widely discussed. The significance of research such as limnology, bathymetry and ecohydrology that could give a better understanding in both lakes and wetland. It is important to stress the issues of governance as most Acts on lakes and wetland are under the jurisdiction of state acts. Case studies in Malaysia and other countries are taken into account. The watershed poses an important scenario to climate change; therefore the microclimate influence plays an important role. Watersheds are confine to areas surrounding ridges, which needs to be mapped using GIS and remote sensing to look at large areas as a whole. Both flora and fauna are related to forest and its climate.

References

Cunningham, W.P., Cunningham, M.A. & Saigo, B.W. 2003. *Environmental Science: A Global Concern*. 7th. Ed. Boston: McGraw-Hill Companies, Inc.

Reeve, R.N. & Barnes, J.D. 1994. *Environmental Analysis*. Chichester, New York: John Wiley & Sons.

UNEP-IETC. 1999. *Planning and Management of Lakes and Reservoirs. An Integrated Approach To Eutrophication*. IETC Pechnical Publication Series. Issue 11

IUCN. 2000. *Vision For Water and Nature. A World Strategy For Conservation and Sustainable Management of Water Resources in The 21st Century*. World Conservation Union.

Gippsland Lakes Ramsar Site: Strategic Management Plan. 2003. Dept. of Sustainability and Environment, East Melbourne.

STAE6303 Procedures and Techniques in EIA

The focus of this course is on the procedure and technique of EIA based on the existing environmental law. These include screening, elaboration on prescribed activity, scoping, preliminary and detailed EIA, evaluation of impact, mitigation and data reporting. Procedures on environmental auditing and monitoring will also be discussed. Social impact analysis shall also be looked at in order to achieve a comprehensive study on the environment in relation to sustainable development.

References

Barrow, C.J. 1997. *Environmental and Social Impact Assessment, An Introduction*. London: Arnold.

Burdge, R. J. 1998. *A Conceptual Approach To Social Impact Assessment*. Revised edition. Middleton: Social Ecology Press.

Glasson, J., R. Therivel & A. Chadwick (pnyt.). 1999. *Introduction to Environmental Impact Assessment*. London: UCL Press.

Razali Agus & Yahya Ibrahim (pnyt.). 2003. *Penilaian Dampak Sosial*. Kuala Lumpur: Utusan Publication & Distribution.

Taylor, C. N., C. H. Bryan & C. C. Goodrich. 1995. *Social Assessment: Theory, Process And Technique*. Christchurch: Taylor Baines.

STAE6323 Assessment and Monitoring of Air and Water Quality

This course will commence with discussions on types of noise, air and water pollution, their principle sources, indexes used to assess their qualities as well as the pertinent law and regulations. Various monitoring techniques including use of bioassays, biomarkers and biosensors will be discussed. Field and laboratory measurements of water, air and noise parameters, calculation of the various indexes and computer modeling for noise, air and water quality will be undertaken. Students are also required to write an essay of not more than 5000 words on a related project paper of their choice; either in group or individually.

References

Brimblecombe, P. 1996. *Air Composition and Chemistry*. 2nd. Ed. Cambridge: Cambridge University Press.

Finlayson-Pitts, B. J. & Pitts, J. N. 2000. *Chemistry of the Upper and Lower Atmosphere, Theory, Experiments and Application.* San Diego: Academic Press.

Harrop, D.O., 2002. *Air Quality Assessment and Management: A Practical Guide*. London and New York: Spon Press.

Spengler, J.D., McCarthy, J.F. & Samet, J.M. 2000. *Indoor Air Quality: A Health Perspective (The Johns Hopkins Series in Environmental Toxicology) (Paperback).* United States of America: The John Hopkins University press.

Sawyer, C.N., McCarty, P.L. & Parkin, G.F. 2003. *Chemistry for Environmental Engineering and Science.* 5th. Ed. McGraw-Hill Higher Education.

MASTER OF SCIENCE (MARINE SCIENCES)

Introduction

As a superior Public Institution of Higher Learning (IPTA) in Malaysia, UKM has moved to the front in encouraging schools to offer post graduate studies in science. UKM offers a marine science programme for under graduate students. The Marine science programme was established in 1985 courses offered include all aspects of marine physics, chemistry and biology at the UKM branch campus at Kota Kinabalu Sabah. This programme was moved back to the main campus in Bangi at the end of 1995. It is currently operating under the School of Environment and Natural Resource Sciences, Faculty of Science and Technology.

Since its establishment, the Marine Science Programme of UKM has experienced developments in various aspects that include expanding of the academic staff expertise and good teaching, numbers of knowledgeable students and high level of researchs. Nowaday, academic staffs from Marine Science Programme of UKM has reputed at national and international standings in various field such as researchs on marine organism diversity,

fisheries science and fish ecology, research on toxic algae problems, marine microbiology and biotechnology and climate changes researchs in particular related with El Nino and La Nina phenomena. Recognition has been proven based on the various roles playing by the academic staffs as leader or coordinator in various global programmes organized by CoML, JSPS, IAEA and IOC-WESTPAC. Several academic staffs from this programme have regularly receiving invitation or deliver talks on various issues at national and international standings. With these achievements, development in knowledge and research, Marine Science Program of UKM are now offered the post-graduates programme studies in marine science.

Entry Requirements

Candidates who applying to this programme must possess:

a) Bachelor degree in sciences, with a good CGPA from Universiti KebangsaanMalaysia or other universities approved by the Senate, or
b) Other qualification that is equivalent to a bachelor degree or has working experience in related field that is approved by the Senate.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: To produce a graduate who has mastered the marine science knowledge holistically
PEO2: To produce a graduate who has competence in soft skills
PEO3: To produce a graduate who has the awareness towards environment
PEO4: To produce a graduate who is able to contribute to other disciplines in order to give impetus to the national and global development
PEO5: To develop effective communication skills of national and international standings.

PROGRAMME OUTCOME (PO)

PO1: Mastery of basic knowledge in marine science.
PO2: Technical competence in marine science with the ability to employ scientific methods to design, conduct experiments, analyse stastistically, interpret data and contribute new information in the field of marine science.
PO3: Ability to identify problems in marine science and to solve the problems critically, creatively and innovatively.
PO4: Ability to work independently as an individual and inter-dependently as in a team.
PO5: Ability to communicate effectively in verbal and in writing to the scientific and public communities.
PO6: Ability to obtain, manage and utilize the latest information systematically and effectively.
PO7: High motivation for life-long learning.
PO8: Ability to address issues on and understand the need of cultural and environmental ethics in society.
PO9: Basic knowledge in entrepreneurship and management to develop and commercialize research findings for a sustainable community and environment.

Programme Structure

The Master of Science programme offered is a programme based on coursework requiring 12 months (2 semesters). Candidates are required to complete a total of 40 credit hours, comprising 18 credit hours of core courses and 22 credit hour of elective course. Candidates are encouraged to expand their individual interests through research projects which commence in the first semester and are supervised by UKM academic staff together with

experts/scientists from relevant institutes. Candidates are required to submit their Research Project Dissertation at the end of the second semester for examination.

SEMESTER	CORE COURSES	ELECTIVE COURSES	TOTAL
I	STPD6014 Research Methodology STAP6064 Geographical Information Systems and Remote Sensing STAP6974 Research Project I	STAL6013 Advance Marine Ecology STAL6033 Marine Microbiology and Biotechnology STAL6213 Coastal and Estuarine Oceanography	**21**
II	STAP6986 Research Project II	STAL6023 Mariculture STAL6043 Management and Conservation of Marine Resources STAL6103 Advance Marine Chemistry STAL6034 Data Analysis Methods in Marine Sciences	**19**
TOTAL	**18**	**22**	**40**

Cources Offered

STPD6014 Research Methods
STAP6064 Geographical Information Systems and Remote Sensing
STAP6974 Research Project I
STAP6986 Research Project II
STAL6013 Advance Marine Ecology
STAL6023 Mariculture
STAL6033 Marine Microbiology and Biotechnology
STAL6034 Data Analysis Methods in Marine Sciences
STAL6043 Management and Conservation of Marine Resources
STAL6103 Advance Marine Chemistry
STAL6213 Coastal and Estuarine Oceanography

Course Contents

STAL6013 Advance Marine Ecology

In this course, marine ecology will be discussed in detail with emphasis on tropical and sub-tropical oceans. Main aspects discussed include the primary and secondary productivities. This is followed by discussion regarding the consumer population dynamics, consumer competition, and the relationship between consumer and producer. Furthermore, marine community dynamics and structure will be discussed which include trophic structure, taxonomy structure, space dynamics and community development. Biogeochemistry process and cycle that function in the marine environment will be discussed. Short term and long term changing processes occurring in the marine environment and the effects of these changes will be emphasized at the end of the course.

References

Barnabé, G. & Barnabé-Quet, R. 2000. *Ecology and Management of Coastal Waters: The Aquatic Environment.* London: Praxis Publishings.
Levinton, J.S. 2001. *Marine Biology: Function, Biodiversity, Ecology.* Oxford: Oxford University Press.
Tait, R.V. & Dipper, F. 1998. *Elements of Marine Ecology.* London: Butterworth-Heinemann.
Valiela, I. 1995. *Marine Ecological Processes.* 2nd. Ed. New York: Springer-Verlag.
Wolanski, E. 2000. *Oceanographic Processes of Coral Reefs.* Boca Raton: CRC Press.

STAL6023 Mariculture

This course will discuss in detail the recent development of marine organism culture such as selected fish species, bivalves, cephalopods, crustacean and other potential marine species. Topics discussed begin with several relevant technical aspects in site selection, pond or floating cage preparation in marine ecosystem, handling and control of cultured stock species, aquaculture nutrition and feed formulation, transportation of life cultured organism and economical mariculture management aspect. The course will also include several case studies in relation to field visits in selected mariculture sites in Peninsula Malaysia.

References

Coimbra, J. (Ed.). 2000. *Modern Aquaculture in Coastal Zone*: *Lesson and Opportunities*. Amsterdam: IOS Press.
De Silva, S. S. 1998. *Tropical Mariculture*. New York: Academic Press.
McVey, J.P. 1992. *Handbook of Mariculture Vol 2: finfish aquaculture*. Baco Raton: CRC Press.
Parker, R. 2000. *Aquaculture Science*. 2nd. Ed. New York: Delmar Publisher.
Stickney, R.R. & McVey, J.P. (Eds.). 2002. *Responsible Marine Aquaculture*. New York: CABI Publisher.

STAL6033 Marine Microbiology and Biotechnology

This course will discuss in more detail on microorganism activity in the ocean. Studies in molecule marine microbiology involve processes including the bioremediation in hydrocarbon degradation, interaction between microbe and metals, and adaptation of microbe on extreme pressure and temperature will be emphasized. Moreover, metabolite bioactive aspects involved in the marine microorganism symbiotic interaction will also be discussed. Studies are corresponding with the biotechnology approach particularly in systematic characteristic of marine microorganism and bioremediation. Practical methods will be emphasized on the DNA extraction, PCR process, gene sequencing, data analysis and management.

References

Barlett, D.H. 1999. *Molecular Marine Microbiology.* JMMB Symposium Series Jil. 1. England: Horizon Scientific Press.
Beveridge, T.J. & Doyle, R.J. (Ed.). 1989. *Metal Ions and Bacteria.* New York: John Wiley & Sons, Inc.
Dunny, G.M. & Winans, S.C. (Ed.). 1999. *Cell-cell Signaling in Bacteria.* Washington D.C: American Society Microbiology Press.
Griffin, A.M. & Griffin, H.G. (ed.). 1995. *Molecular Biology: Curing Innovative and Future Trend.* England: Horizon Scientific Press.
Le Gal, Y. & Halvorson, H.O. (Ed.). 1998. *New Developments in Marine Biotechnology*. New York: Plenum Press.

STAL6034 Data Analysis Methods in Marine Sciences

Oceanographic and climatological/meteorological studies often involved in manipulation and utilization of complex spatial-temporally distributed datasets. These datasets are archived in various formats in order to facilitate transmission of abundant data over the internet. This course introduces processing of these data formats. Several software packages that are oftenly used will be introduced. Besides, modern analysis techniques for spatial and temporally distributed data will also be discussed. These techniques include spatial analysis, modern time series analysis as well as the concurrent spatial-temporal analysis.

References

Emery, W.J. & Thompson, R.E. 2004. *Data Analysis Methods in Physical Oceanography.* Armsterdam: Elsevier.

Mitchell, A. 2005. *GIS Analysis. Spatial Measurements & Statistics.* California:ESRI Press.

Wilks, D.S. 2006. S*tatistical Methods in the Atmospheric Sciences*. 2nd. Ed. London: Elsevier, Academic Press.

Tabachnick, B.G. & Fidell, L.S. 2007. *Using Multivariate Statistic*. 5th. Ed. London: Allyn and Bacon.

Trauth, M.H., Gebbers, R., Sillmann, E. & Marwan N. 2006. *Matlab Recipes for Earth Sciences.* Verlag: Birkhäuser.

STAL6043 Management and Conservation of Marine Resources

This course will discuss mainly human exploitation activities on coastal and offshore fisheries resources. Global history and fishery resource exploitation flow of the selected fishes species, status and levels of world fisheries resource management, and fishery modeling tools used in marine fishery stock assessment will also be discussed. Detailed discussion will focus on current development on several aspects of marine resource management that include policy and legal aspects of management and conservation of marine resources.

References

De Silva, S. S. 1998. *Tropical Mariculture.* New York: Academic Press.

Gulland, J.A. (Ed.). 1988. *Fish Population Dynamics: The Implications for Management*. Chichester: John Wiley & Sons Ltd.

Ross, M.R. 1996. *Fisheries Conservation and Management.* New York: Prentice Hall.

Scovazzi, T. 1999. *Marine Specially Protected Area: The General Aspects and The Mediterranean Regional System.* New York: Kluwer Law International.

Torell, M. & Salamanca, A.M. (Eds.) 2002. Institutional issues and perspectives in the management of fisheries and coastal resources in Southeast Asia. ICLARM Technical Report 60.

STAL6103 Advance Marine Chemistry

This course covers advance aspects of marine chemistry which is focused on the important aspects of ocean systems. The controlled process composition of seawater and chemical species in ocean will be discussed. The discussion will focus on the marine chemical characteristics that occurred which is related to the seafloor, atmosphere and marine organisms. Discussion on latest research related to marine chemistry field will also be conducted.

References

Alison, B.D. & Alyn, C.D. 1999. *Fundamentals of Oceanography.* New York: McGraw-Hill.

Chester, R. 1989. *Marine Geochemistry.* London: Unwin Hyman.

Frank, J.M. & Mary, L.S. 1991. *Chemical Oceanography.* Boca Raton: CRC Press.

Ivanovich, M. & Harmon, R.S. 1982. *Uranium Series Disequilibrium: Application to Environmental Problem.* Oxford: Clarendon Press.

Summerhayes, C.P. & Thorpe, S.A. 1996. *Oceanography*. New York: Manson Publ.

STAL6213 Coastal and Estuarine Oceanography

This course provides in-depth understanding of physical oceanographic processes at coastal, shelf sea and estuary. The first part of this course covers the physical aspects of estuary. These include estuary classification, circulation, stratification, mixing processes as well as wave and tidal influences. The sediment and pollutant transport in estuary will also be discussed. The second part of this course covers oceanographic processes at coastal and shelf sea. These include mixing processes, wave and tidal influences, circulation and currents, stratification and fronts. Exchanges between shelf sea and open ocean will also be discussed.

References

Brown J., Colling, A., Park, D., Phillips, J., Rothery, D. & Wright, J. (Open University Course Team). 1997. *Waves, Tides and Shallow-Water Processes*. Chichester: Butterworth-Heinemann Ltd.

Massel, S.R. 1989. *Hydrodynamics of Coastal Zones*. Amsterdam: Elsevier Scientific Publ. Co.

Pickard, G.L. & Emery, W.J. 1982. *Descriptive Physical Oceanography*. New York: Pergamon Press.

Prandle, D. 1995. *Dynamics and Exchanges in Estuaries and Coastal Zone*. Berlin: Springer Verlag.

Soulsby, R.L. 1997. *Dynamics of Marine Sands: A Manual for Practical Applications*. London: Thomas Telford Publications.