

CURRICULUM

OF

BOTANY
BS (4-YEAR)

2008



HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

Curriculum development is a highly organized and systematic process and involves a number of procedures. Many of these procedures include incorporating the results from international research studies and reforms made in other countries. These studies and reforms are then related to the particular subject and the position in Pakistan so that the proposed curriculum may have its roots in the socio-economics setup in which it is to be introduced. Hence, unlike a machine, it is not possible to accept any curriculum in its entirety. It has to be studied thoroughly and all aspects are to be critically examined before any component is recommended for adoption.

In exercise of the powers conferred by sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide notification No. D773/76-JEA (cur.), dated December 4th 1976, appointed the University Grants Commission as the competent authority to look after the curriculum revision work beyond class XII at the bachelor level and onwards to all degrees, certificates and diplomas awarded by degree colleges, universities and other institutions of higher education.

In pursuance of the above decisions and directives, the Higher Education Commission (HEC) is continually performing curriculum revision in collaboration with universities. According to the decision of the special meeting of Vice-Chancellor's Committee, the curriculum of a subject must be reviewed after every 3 years.

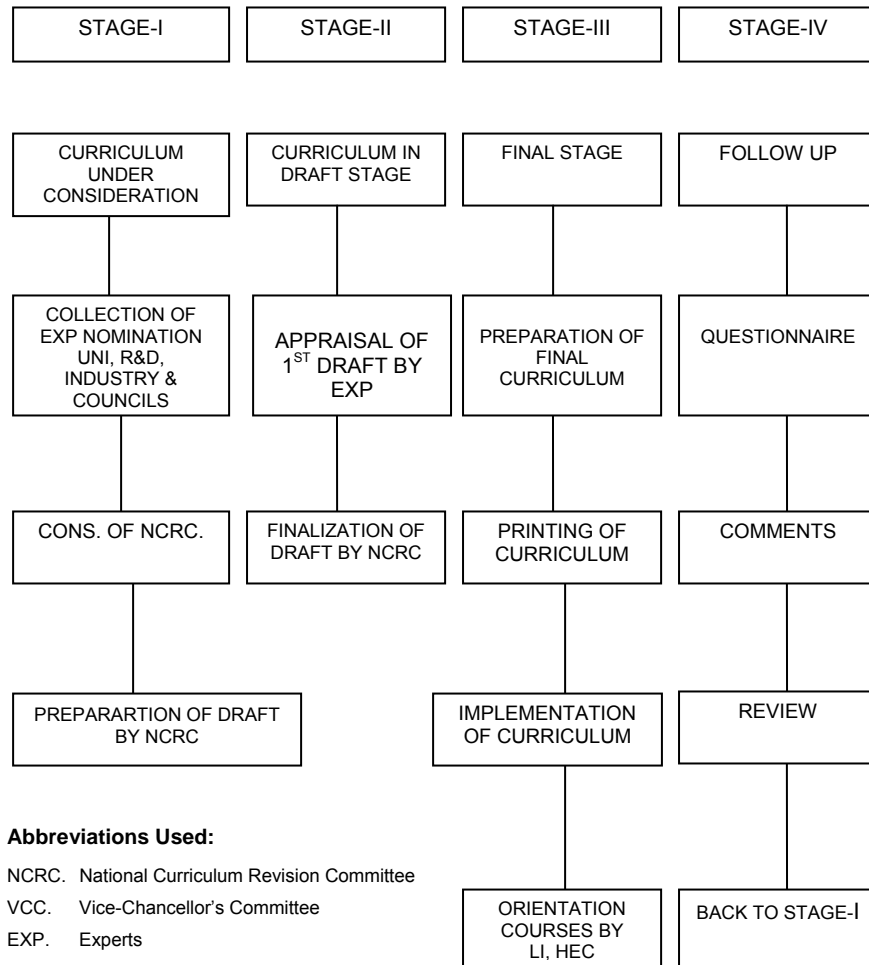
A committee of experts comprising of conveners from the National Curriculum Revision of HEC in Basic, Applied Social Sciences and Engineering disciplines met in April 2007 and developed a unified template to standardize degree programs in the country to bring the national curriculum at par with international standards, and to fulfill the needs of the local industries. It also aimed to give a basic, broad based knowledge to the students to ensure the quality of education. The new BS degree shall be of 4 years duration, and will require the completion of 130-136 credit hours. For those social sciences and basic sciences degrees, 63.50% of the curriculum will consist of discipline specific courses, and 36.50% will consist of compulsory courses and general courses offered through other departments.

For the purpose of curriculum revision various committees are constituted at the national level, comprising of senior teachers nominated by universities, degree awarding institutions, R&D organizations and respective accreditation councils. The National Curriculum Revision Committee for Botany in a meeting held on May 6-7.2008 at the HEC Regional Center, Lahore in continuation of its earlier meeting held on Nov 20-21,2007 at HEC Regional Center, Karachi, revised the curriculum in light of the unified template. The final draft prepared by the National Curriculum Revision Special Committee, duly approved by the competent authority, is being circulated for implementation in the concerned institutions.

DR. RIAZ-UL-HAQ TARIQ
Member Academics

June 2008

CURRICULUM DEVELOPMENT



Abbreviations Used:

- NCRC. National Curriculum Revision Committee
- VCC. Vice-Chancellor's Committee
- EXP. Experts
- COL. Colleges
- UNI. Universities
- PREP. Preparation
- REC. Recommendations
- LI Learning Innovation
- R&D Research & Development Organization
- HEC Higher Education Commission

**NATIONAL CURRICULUM REVISION COMMITTEE
MEETING IN BOTANY HELD FROM
MAY 6-7, 2008 AT HEC
REGIONAL CENTRE, LAHORE
MINUTES OF THE MEETING**

INTRODUCTION

A National Curriculum Revision Committee (NCRC) meeting in Botany was held from May 6-7, 2008 at HEC, Regional Centre, Lahore to finalize the draft curriculum in the light of generic frame work/template developed by the conveners of NCRC in Basic, Social, Natural and Applied Sciences. The following attended the meeting.

- | | | |
|----|--|----------|
| 1. | Prof. Dr. Ihsan Ilahi
Kohat University of Science & Technology
Banu Road, Off Jarma,
Kohat | Convener |
| 2. | Dr. Zaheer-ud-Din Khan
Professor & Chairman
Department of Botany,
Government College University,
Lahore | Member |
| 3. | Dr. Muhammad Ashraf
Professor of Botany & Dean
Faculty of Sciences
University of Agriculture,
Faisalabad | Member |
| 4. | Prof. Dr. Khan Rass Masood,
Chairman,
Department of Botany,
University of the Punjab,
Lahore | Member |
| 5. | Prof. Basir Ahmed Arrain
Professor
Institute of Botany
University of Sindh,
Jamshoro | Member |

- | | | |
|-----|---|----------------------|
| 6. | Prof. Dr. Ikram-ul-Haq,
Professor
Department of Botany,
Government College University,
Lahore | Member |
| 7. | Prof. Dr. Saeed Malik
Professor
Department of Botany
BZ University, Multan | Member |
| 8. | Prof. Dr. Mohammad Ashraf
Chairman
Department of Plant Sciences,
Quaid-i-Azam University
Islamabad | Member |
| 9. | Prof. Dr. Surayya Khatoon
Department of Botany
University of Karachi, Karachi | Member |
| 10. | Dr. G. Raza Bhatti
Professor
Director, Herbarium & Botanical Garden
Department of Botany
Shah Abdul Latif University,
Khairpur | Member |
| 11. | Prof. Dr. Rashida Zafar,
Department of Botany,
Lahore College for Women University,
Lahore | Member |
| 12. | Dr. Bilquees Gul
Department of Botany
University of Karachi
Karachi | Member |
| 13. | Dr. Ghulam Murtaza
Assistant Professor,
Department of Botany
University of Azad Jammu Kashmir
Muzaffarabad | Member |
| 14. | Prof. Dr. Farrukh Hussain
Chairman
Department of Botany
University of Peshawar,
Peshawar | Member/
Secretary |

The meeting started with the recitation from the Holy Quran by Mr. Tahir Ali Shah. Afterwards Fatiha was offered for Prof. Dr. K.M.Aslam (Member, NCRC in Botany), Prof. T.M.Khattak, Department of Botany, University of AJK, Muzaffarabad and Mr. Faisal A. Khan, IT Administrator, HEC Karachi. May God rest their souls in eternal peace.

As required the Committee developed the template for BS Botany 4 year programme on the provided performa. This included compulsory, general, foundation, major and elective courses to be adopted by both the public and private sector universities of the country. This Programme of 4 year BS comprised 130 credit hours spread over 8 semesters.

The rationale, goals and outcome of the course (on separate sheets) be included while the syllabus is printed. The Committee also made general recommendations for the consideration of the HEC authorities.

The meeting ended with a vote of thanks to HEC for organizing the meeting and extending hospitality during the meeting. May Allah bless all of us.

Outcome of the Course

The BS programme will enable to the students to be acquainted with the latest knowledge of the plant sciences. In the programme the knowledge of foundation courses as Diversity, Plant Anatomy, Biochemistry and Biostatistics etc. and the major courses as Physiology, Genetics, and Ecology etc. is incorporated. The four elective courses are left for specific requirement of the students of a university.

Goal

The goal of BS 4 year programme is to produce competent professionals in the field of Botany who will be capable to face the challenges of the changing world.

Rationale

The subject of plant sciences has undergone tremendous advances all over the world. It is imperative to update the existing national curriculum in Botany to bring it at par with the international standards.

**TEMPLATE FOR 4-YEAR BS DEGREE
PROGRAM IN BOTANY**

SR.	CATEGORIES	NO. OF COURSES MIN- MAX	CREDIT HOURS MIN- MAX
1.	Compulsory Requirement (No Choice)	9 – 9	25 – 25
2.	General Courses to be chosen from other departments	7 – 8	21 – 24
3.	Discipline Specific Foundation Courses	9 – 10	30 – 33
4.	Major Courses including research project / Internship	11 – 13	36 – 42
5.	Electives within the major	4 – 4	12 – 12
	Total	40 – 44	124 – 136

- Total numbers of Credit hours 130
- Duration 4 years
- Semester duration 16-18 weeks
- Semesters 8
- Course Load per Semester 12-18 Cr hr
- Number of courses per semester 4-6 (not more than
3 – Lab / Practical
Courses per Semester)

LAYOUT FOR BS BOTANY (4 – YEAR PROGRAMME)

Compulsory Requirements (the student has no choice)		General Courses to be Chosen From Other Departments	
9 courses		7-8 courses	
25 Credit hours		21-24 Cr. Hours	
Subjects	Cr. hr	Subjects	Cr. hr
1. ENGLISH I (Functional English)	3	1. Genera Course-I ***	3
2. ENGLISH II(Communication Skill)	3	2. Genera Course-II***	3
3. ENGLISH III (Technical Report Writing & presentation skills)	3	3. Genera Course-III ***	3
4. ENGLISHVI*	3	4. Genera Course-IV ***	3
5. PAKISTAN STUDIES	2	5. Genera Course-V ***	5
6. ISLAMIC STUDIES / ETHICS	2	6. Genera Course-VI ***	3
7. MATHEMATICS I ** (Statistical Packages)	3	7. Genera Course-VII ***	3
8. MATHEMATICS II(Biostatistics)	3	8. Genera Course-VIII***	3
9. INTRODUCTION TO COMPUTER	3		
	25		25

Discipline Specific Foundation Courses		Major courses	
9-10 courses		11-13 courses	
30-33 Credit hours		36-42 Credit hours	
Subjects	Cr. hr	Subjects	Cr. hr
1. Diversity of Plants	4	1. Phycology & Bryology	3
2. Plant Systematics, Anatomy & Development	4	2. Mycology & Plant Pathology	3
3. Cell Biology, Genetics & Evolution	4	3. Plant Systematics	3
4. Plant Physiology & Ecology	4	4. Genetics-I	3
5. Biodiversity & Conservation	4	5. Plant Biochemistry-I	3
6. Bacteriology & Virology	3	6. Plant Physiology-I	3
7. Diversity of Vascular Plants	3	7. Molecular Biology	3
8. Plant Anatomy	3	8. Plant Biochemistry-II	3
9. Plant Ecology-I	3	9. Plant Ecology-II	3
		10. Plant Physiology-II	3
		11. Genetics-II	3
		12. Environmental Biology	3
	32		36

Elective Courses within the major including research project/internship	
4 courses	
12 Credit Hours	
Subject	Cr. hr
1. Elective-I / Research Project / Internship/ *Optional	3
2. Elective-II University option	3
3. Elective-III Research Project / Internship/ *Optional	3
4. Elective-IV University Option	3
	12

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

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

*** To be chosen from list of General Courses

**SCHEME OF STUDIES FOR 4 YEAR INTEGRATED BS
PROGRAMME**

Semester	Name of Subject	Theory	Lab	Cr. hr
First	ENGLISH-I (Functional English)	3	0	3
	PAKISTAN STUDIES	2	0	2
	MATH/STAT-1 (Statistical Packages)**	3	0	3
	GENERAL-I***	3	0	3
	GENERAL-II***	3	0	3
	FOUNDATION-I Bot-301 Diversity of Plants	3	1	4
				1
Second	ENGLISH-II (Communication Skills)	3	0	3
	ISLAMIC STUDIES / ETHICS	2	0	2
	ENGLISH IV UNIV. OPTIONAL*	3	0	3
	GENERAL-III***	3	0	3
	GENERAL-IV	3	0	3
	FOUNDATION-II Bot-302 Plant Systematics, Anatomy and Development	3	1	4
		17	1	18
Third	ENGLISH-III (Technical Report Writing & Presentation Skill)	3	0	3
	INTRODUCTION TO COMPUTER	3	0	3
	GENERAL-V ***	3	1	4
	GENERAL-VI ***	3	0	3
	FOUNDATION-III Bot-401 Cell Biology, Genetics and Evolution	3	1	4
		15	2	17
	Fourth	MATHEMATICS II (Bio Statistics)	3	0
GENERAL-VII***		3	0	3
GENERAL-VIII***		3	0	3
FOUNDATION-IV Bot-402 Plant Physiology and Ecology		3	1	4
FOUNDATION-V Bot-403 Biodiversity and Conservation		3	1	4
		15	2	17

Fifth	FOUNDATION-VI Bot-502 Bacteriology and Virology	3	0	3
	FOUNDATION-VII Bot-505 Diversity of Vascular Plants	3	0	3
	MAJOR-I Bot-503 Phycology and Bryology	3	0	3
	MAJOR-II Bot-504 Mycology and Plant Pathology	3	0	3
	MAJOR-III Bot-506 Plant Systematics	3	0	3
	FOUNDATION-VIII Bot-507 Plant Anatomy	3	0	3
		18	0	18
Sixth	FOUNDATION-IX Bot-510 Plant Ecology-I	3	0	3
	MAJOR-IV Bot-508 Genetics-I	3	0	3
	MAJOR-V Bot-509 Plant Biochemistry-I	3	0	3
	MAJOR-VI Bot-511 Plant Physiology-I	3	0	3
	MAJOR-VII Bot-601 Molecular Biology	3	0	3
		15	0	15
Seventh	MAJOR-VIII Bot-602 Plant Biochemistry-II	3	0	3
	MAJOR-IX Bot-603 Plant Ecology-II	3	0	3
	ELECTIVE-I, RESEARCH PROJECT/ INTERNSHIP / *OPTIONAL PAPER	0	3	3
	ELECTIVE-II	3	0	3
	MAJOR-X Bot-604 Plant Physiology-II	3	0	3
		12	3	15
Eighth	MAJOR-XI Bot-606 Genetics-II	3	0	3
	MAJOR-XII Bot-607 Environmental Biology	3	0	3

	ELECTIVE-III RESEARCH PROJ / INTERNSHIP/*OPTIONAL PAPER	0	3	3
	ELECTIVE-IV	3	0	3
	Total	9	3	12
				130

- * University has the option to recommend any other course in lieu of English IV
- ** University may recommend any other course in lieu of Mathematics I
- *** To be chosen from list of General Courses

Note: - Optional and elective papers to be framed by respective Board of Studies.

**DETAIL OF COURSES
FOR BS (4 YEAR IN BOTANY)**

1st Year

1st Semester

Title of the Course: Bot-301 Diversity of Plants

Credit Hours: 4(3+1)

Prerequisites: Inter / A levels with Biology

Specific Objectives of course: To introduce the students to the diversity of plants and their structures and significance.

Course Outline:

Comparative study of life form, structure, reproduction and economic significance of:

- a) Viruses (RNA and DNA types) with special reference to TMV;
- b) Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance;
- c) Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia)
- d) Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.
- e) Lichens (Phycia)
- f) Bryophytes
 - i. Riccia
 - ii. Anthoceros
 - iii. Funaria
- g) Pteridophytes.
 - i. Fossils and fossilization
 - ii. Psilopsida (Psilotum)

- iii. Lycopsidea (Selaginella)
- iv. Sphenopsida (Equisetum)
- v. Pteropsida (Marsilea)
- vi. Seed Habit
- h) Gymnosperms
 - i. Cycas
 - ii. Pinus
 - iii. Ephedra

Lab Outline:

Culturing, maintenance, preservation and staining of microorganisms. Study of morphology and reproductive structures of the types mentioned in theory. Identification of various types mentioned from prepared slides and fresh collections.

Recommended Books:

1. Lee, R.E. 1999. Phycology. Cambridge University Press, UK
2. Prescott, L.M., Harley, J.P. and Klein, A.D. 2004. Microbiology, 3rd ed. W.M. C. Brown Publishers.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. 4th ed. John Wiley and Sons Publishers.
4. Agrios, G.N. 2004. Plant pathology. 8th ed. Academic press London.
5. Vashishta, B.R. 1991. Botany for degree students (all volumes). S. Chand and Company. Ltd. New Delhi.
6. Andrew, H. N. 1961. Studies in Paleobotany. John Willey and Sons.
7. Ingrouille , M. 1992. Diversity and Evolution of Land Plants. Chapman & Hall .
8. Mauseth, J.D. 2003. Botany: An Introduction to Plant Biology 3rd ed., Jones and Bartlett Pub. UK
9. Marti.J.Ingrouille & Plant: Diversity and Evolution. 2006 CUP
10. Taylor, T.N. & Taylor, E.D. 2000. Biology and Evolution of Fossil Plants. Prentice Hall. N.Y.

Journals / Periodicals: Pakistan Journal of Botany, American Journal of Botany, Canadian Journal of Botany, Annals of Botany

2nd Semester

Title of the Course: Bot – 302 Plant Systematics,
Anatomy and Envelopment

Credit Hours: 4(3+1)

Prerequisites: Bot – 301

Specific objectives of course: To understand 1- various systems of classification, identification and nomenclature of higher plants, 2- Structures and functions of tissues and organs at embryonic level.

Course outline:

a) Plant systematics

1. Introduction to Plant Systematics: aims, objectives and importance.
2. Classification: brief history of various systems of classification with emphasis on Takhtajan.
3. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to International Code of Botanical Nomenclature (ICBN).Vienna code.
4. Morphology: a detailed account of various, orphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
5. Diagnostic characters, economic importance and distribution pattern of the following families:
 - i. Ranunculaceae
 - ii. Brassicaceae (Cruciferae)
 - iii. Fabaceae (Leguminosae)
 - iv. Rosaceae
 - v. Euphorbiaceae
 - vii. Cucurbitaceae
 - vii. Solanaceae
 - viii. Lamiaceae (Labiatae)
 - ix. Apiaceae (Umbelliferae)
 - x. Asteraceae (Compositae)
 - xi. Liliaceae (Sen. Lato)
 - xii. Poaceae (Gramineae)

b) Anatomy

1. Cell wall: structure and chemical composition
2. Concept, structure and function of various tissues like:
 - i. Parenchyma
 - ii. Collenchyma
 - iii. Sclerenchyma
 - iv. Epidermis (including stomata and trichomes)
 - v. Xylem
 - vi. Phloem
3. Meristem: types, stem and root apices
4. Vascular cambium
5. Structure and development of root, stem and leaf.
Primary and secondary growth of dicot stem, periderm
6. Characteristics of wood: diffuse porous and
ring –porous, sap and heart wood, soft and hard wood,
annual rings.

c) Development / Embryology

Early development of plant body:

1. Capsella bursa-pastoris
2. Structure and development of Anther Microsporogenesis
Microgametophyte
3. Structure of Ovule Megasporogenesis
Megagametophyte
4. Endosperm formation
5. Parthenocarpy
6. Polyembryony

Lab Outline:

Anatomy

1. Study of stomata, epidermis,
2. Tissues of primary body of plant
3. Study of xylem 3-dimensional plane of wood.
4. T.S of angiosperm stem and leaf.

Taxonomy

1. Identification of families given in syllabus with the help of keys.

2. Technical description of common flowering plants belonging to
3. families mentioned in theory syllabus.
4. Field trips shall be undertaken to study and collect local plants.
5. Students shall submit 40 fully identified herbarium specimens.

Recommended Books:

1. Mauseth, J.D. 1998. An Introduction to Plant Biology: Multimedia Enhanced. Jones and Bartlett Pub. UK
2. Moore, R.C., W.D. Clarke and Vodopich, D.S. 1998. Botany. McGraw Hill Company, U.S.A.
3. Raven, P.H., Evert, R.E. and Eichhorn, S.E. 1999. Biology of Plants. W.H. Freeman and Company Worth Publishers.
5. Stuessy, T.F. 1990. Plant Taxonomy. Columbia University Press, USA.
6. Lawrence, G.H.M. 1951 Taxonomy of Vascular Plants. MacMillan & Co. New York.
7. Panday, B.P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
8. Raymond E, S. E. Eichhorn. 2005. Esau's Plant Anatomy. Meristems cells and tissues of the plant body, 3rd ed. John Wiley & Sons. Inc.
9. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
10. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
11. Maheshwari, P.1971. Embryology of Angiosperms, McGraw Hill. New York.
12. Eames A.J. and L.H Mac Daniels. 2002. An Introduction to Plant Anatomy. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.
13. Pullaiah, T. 2007. Taxonomy of Angiosperms. 3rd Edition Regency Publications, New Delhi.
14. Naik, V.N. 2005 Taxonomy of Angiosperms. 20th Reprint. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.

Journals / Periodicals: **Pakistan Journal Of Botany,
Taxon, Phytton.**

**2ndYear
3rd Semester**

Title of the course: BOT-401 Cell Biology, Genetics
and Evolution

Credit hours: 4(3+1)

Prerequisites: BOT- 301 & 302

Specific objectives of course: To understand 1- structure and functions of cell, 2-nature of genetic material and hereditary process 3- familiarization with evolutionary processes.

Course outline:

a) Cell biology

1. Structures and Functions of Bio-molecules
 - i. Carbohydrates
 - ii. Lipids
 - iii. Proteins
 - iv. Nucleic Acids
2. Cell: Physico-chemical nature of plasma membrane and cytoplasm.
3. Ultrastructure of plant cell with a brief description and functions of the following organelles
 - i. Cell wall
 - ii. Endoplasmic reticulum
 - iii. Plastids
 - vi. Mitochondria
 - v. Ribosomes
 - vi. Dictyosomes
 - vii. Vacuole
 - viii. Microbodies (Glyoxysomes and Peroxisomes)
4. Nucleus: Nuclear membrane, nucleolus, ultrastructure and morphology of chromosomes, karyotype analysis
5. Reproduction in somatic and embryogenic cell, mitosis and meiosis, cell cycle
6. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.

b) Genetics

1. Introduction, scope and brief history of genetics. Mendelian inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance.

2. Sex linked inheritance, sex linkage in *Drosophila* and man (colour blindness), XO, XY, WZ mechanisms, sex limited and sex linked characters, sex determination.
3. Linkage and crossing over: definition, linkage groups, construction of linkage maps, detection of linkage.
4. Molecular genetics; DNA replication. Nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. *lac* operon).
5. Transmission of genetic material in Bacteria: Conjugation and gene recombination in *E.coli*, transduction and transformation.
6. Principles of genetic engineering / biotechnology; Basic genetic engineering techniques.
7. Application of genetics in plant improvement: Induction of genetic variability (gene mutation, recombination), physical and chemical mutagens, selection, hybridization and plant breeding techniques. Development and release of new varieties.
8. Introduction to germplasm conservation

c) Evolution

The nature of evolutionary forces, adaptive radiations, differential reproductive potential, first plant cell, origin of organized structures, early aquatic and terrestrial ecosystem, first vascular plant.

Lab Outline:

Cell Biology

1. Study of cell structure using compound microscope and elucidation of ultrastructure from electron microphotographs
2. Measurement of cell size.
3. Study of mitosis and meiosis by smear/squash method and from prepared slides.
4. Study of chromosome morphology and variation in chromosome number.
5. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.

Genetics

1. Genetical problems related to transmission and distribution of genetic material.
2. Identification of DNA in plant material. Carmine/orcein staining.
3. Study of salivary gland chromosomes of *Drosophila*.

Recommended Books:

1. Hoelzel, A. R. 2001. Conservation Genetics. Kluwer Academic Publishers.
2. Dyonsager, V.R. (1986). Cytology and Genetics. Tata and McGraw Hill Publication Co. Ltd., New Delhi.
3. Lodish. H. 2001. Molecular Cell Biology. W. H. Freeman and Co.
4. Sinha, U. and Sinha, S. (1988). Cytogenesis Plant Breeding and Evolution, Vini Educational Books, New Delhi.
5. Strickberger, M.V. (1988), Genetics, MacMillan Press Ltd., London.
6. Carroll, S.B., Grenier, J.K. and Welnerbee, S.d. 2001. From DNA to Diversity - Molecular Genetics and the Evolution of Animal Design. Blackwell Science.
7. Lewin, R, 1997. Principles of Human Evolution. Blackwell Science.
8. Strickberger, M. W. 2000 Evolution. Jones & Bartlet Publishers Canada
9. Ingrouille M. J. & B. Eddie. 2006. Plant Diversity and Evolution. Cambridge University Press.

Journals / Periodicals: Theoretical & Applied Genetics, The Cell, Heredity.

4th Semester

Title of the course: Bot-501 Biostatistics

Credit hours: 3(2+1)

Prerequisites:

Specific objectives of course:

Course outline:

1. Introduction objectives and scope:
 - i. Definition

- ii. Characteristics
 - iii. Importance and limitations
 - iv. Population and samples
2. Frequency distribution:
- i. Variable types
 - ii. Formation of frequency table from raw data
 - iii. Summation, notation and statistical inference
 - iv. Data transformation.
3. Measures of central tendencies and dispersion:
- i. Arithmetic mean
 - ii. Median
 - iii. Mode
 - iv. Range
 - v. Variance
 - vi. Standard deviation
 - vii. Standard error of the mean
 - viii. Mean deviation.
4. Organizing and describing data (Standard distributions):
- i. Random sampling and the binomial distribution
 - ii. Probability, Types of Probabilities, Random variables, Combining probabilities, Probability distributions, Binomial distributions.
 - iii. Poisson and normal distributions, properties and applications.
5. Basic experimental design:
- i. Concept and design
 - ii. Principles of experiments
 - iii. Observational studies
 - iv. Planning of experiments
 - v. Replication and randomization
 - vi. Field plot technique
 - vii. Layout and analysis of completely randomized design
 - viii. Randomized complete block design
 - ix. Latin square
 - x. Factorial design
 - xi. Treatment comparison

6. Tests of significance:
 - i. T-test: (Basic idea, confidence limits of means, significant difference of means.
 - ii. Chi square test: Basic idea, testing goodness of fit to a ratio, testing association (contingency table).
 - iii. F-test: Introduction and application in analysis of variance.
 - iv. LSD test, Duncan's New Multiple Range test (for comparison of individual means). Bonferroni test.
7. Introduction to comparing many means:
Unit organization, Basic one way ANOVA, Types of sums of squares, How ANOVA works, The ANOVA Table. Two-way ANOVA-Factorial designs: (two-way factorial analysis, calculating and analyzing the two-way ANOVA, Linear combination, multiple comparisons.
8. Correlation and Regression.

Lab outline:

1. Data collection, arrangement of data in frequency table, calculating frequency, cumulative frequency and preparation of Ogive.
2. Calculating different measure of central tendency such as arithmetic means, harmonic mean, geometric mean, median and mode.
3. Calculation of mean from grouped and ungrouped data.
4. Calculation of variance and standard deviation from grouped and ungrouped data.
5. Calculating dispersion, relative dispersion, standard deviation, standard error, standard score and co-efficient variation by hand and machine method.
6. Problems concerning probability, binomial distribution, poisson distribution, skewness and Kurtosis and T-test.
7. Chi square test.
8. Analysis of variance - one factor design.
9. Multiple Analyses Of Variance.
10. Determination of correlation by constructing different types of graphs such as scatter diagram, linear positive correlation, linear perfect negative correlation, no correlation and curvilinear correlation (second degree polynomial, third degree polynomial).
11. Linear Regression and multiple regression models.

Recommended Books:

1. Harvey, M. 1995. Intuitive Biostatistics. Oxford University Press. NY. Kuzma J.W. and Bohnenblust, S.E. 2001, Basis Statistics for the Health Sciences, McGraw-Hill International Education.
2. Onton, P., Adams, S. and Voelkar, D.H. 2001. Cliffnotes for statistics. Blackwell Scientific Publishers.
3. Pacano, M. and Gauvreau, K. 2000. Principles of Biostatistics.
4. Quinn, G. 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press.
5. Rosner, B. 2005. Fundamentals of Biostatistics. John Wiley & Sons.
6. Samuels, M.L. and Witmar, J.A. 2003. Statistics for life sciences. 3rd Edition. Cambridge University Press.
7. Triola, M.F. and Triola, M.M. 2005. Biostatistics for Biological and Health Sciences. Pearson Addison Wesley.
8. Zar, J.H., 1999. Biostatistical Analysis, Pearson Education.

Title of the course: BOT-402 Plant Physiology And Ecology

Credit hours: 4(3+1)

Prerequisites: Bot-301, 302, 401

Specific objectives of course:

- 1- To provide comprehensive knowledge of functioning of organs, organelles and biomolecules,
- 2- to enable the students to assess the effects of various environmental factors on plant growth and development.

Course outline:

a) Plant Physiology

1. Water relations (water potential, osmotic potential, pressure potential, matric potential). Absorption and translocation of water. Stomatal regulation.

2. Mineral nutrition: Soil as a source of minerals. Passive and active transport of nutrients. Essential mineral elements, role and deficiency symptoms of macronutrients.
3. Photosynthesis: Introduction, Oxygenic and non-oxygenic photosynthesis Mechanism: light reactions (electron transport and photophosphorylation) and dark reactions(Calvin cycle). Differences between C₃ and C₄ plants. Factors affecting this process, Products of photosynthesis.
4. Respiration: Definition and respiratory substrates. Mechanism-Glycolysis, Krebs cycle. Electron transport and oxidative phosphorylation. Anaerobic respiration. Energy balance in aerobic and anaerobic respiration, Respiratory quotients.
5. Growth: Definition; role of auxins, gibberellins, cytokinins, abscisic acid and ethylene in controlling growth. Introduction to plant tissue culture.
6. Photoperiodism: Definition, historical background, Classification of plants based on photoperiodic response, Role of phytochromes, and hormones and metabolites in photoperiodism,
7. Dormancy: Definition and causes of seed and bud dormancy; methods of breaking seed dormancy. Physiological processes during seed germination.
8. Plant Movements: Classification. Tropic movements- phototropism, gravitropism and their mechanisms. Nastic movements.

b) Ecology

1. Introduction, aims and applications of ecology.
2. Soil: Physical and Chemical properties of soil (soil formation, texture. pH, EC, organism and organic matter etc) and their relationships to plants.
3. Light and Temperature. Quality of light, diurnal and seasonal variations. Ecophysiological responses.

4. Water: Field capacity and soil water holding capacity. Characteristics of xerophytes and hydrophytes. Effect of precipitation on distribution of plants.
5. Wind: Wind as an ecological factor and its importance.
6. Population Ecology: Introduction. A brief description of seed dispersal, seed bank, demography, density effects and reproductive strategy.
7. Community Ecology
 - i. Ecological characteristics of plant community
 - ii. Methods of sampling vegetation (Quadrat and line intercept)
 - iii. Succession.
 - iv. Major vegetation types of the local area.
8. Ecosystem Ecology
 - i. Definition, types and components of ecosystem.
 - ii. Food chain and Food web.
 - iii. Biogeochemical cycles, definition, types with emphasis on Nitrogen & Hydrological cycles.
9. Applied Ecology
 - i. Causes, effects and control of water logging and salinity with respect to Pakistan
 - ii. Soil erosion: types, causes and effects (wind and water)
 - iii. Brief concept of pollution types and effects (air, sediments and water pollution)
 - iv. Brief introduction to biodiversity and conservation with emphasis on Pakistan.

Lab Outline:

a) Plant Physiology

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.
3. Measurement of leaf water potential by the dye method.
4. Determination of the temperature at which beet root cells lose their permeability.

5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer/by cobalt chloride paper method.
6. Chemical tests for the following cell constituents:
 - i. Starch
 - ii. Cellulose
 - iii. Lignin
 - iv. Proteins
7. Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram. Study of absorption spectra using spectrophotometer.
8. Estimation of oxygen utilized by a respiring plant by Winkler's method.
9. Extraction of amylase from germinating wheat seeds and study of its effect on starch breakdown.
10. Measurement of carbon dioxide evolution during respiration of germinating seeds by the titration method.
11. Measurement of light and temperature.
12. Effect of light and temperature on seed germination.

b) Ecology

1. Determination of physical and Chemical characteristics of soil.
2. Measurements of various population variables
3. Measurement of vegetation by Quadrat and line intercept methods.
4. Field trips to ecologically diverse habitats.
5. Measurements of wind velocity.

Recommended Books:

1. Ihsan Illahi 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
2. Witham and Devlin. 1986 Exercises in Plant Physiology, AWS Publishers, Boston.
3. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th. Ed. Sinauers Publ. Co. Inc. Calif.
4. Salisbury F.B. and Ross C.B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
5. Hopkins, W.B. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York
6. Schultz, J.C. 2005. Plant Ecology. Springer-Verlag, Berlin.

7. Ricklefs, R.E. 2000. Ecology. W.H. Freeman and Co., UK.
8. Ricklefs, R.E. 2001. The Economy of Nature. W.H. Freeman and Co., UK.
9. Barbour, M. G., J. H. Burke and W.D. Pitts. 1999. Terrestrial Plant Ecology, The Benjamin, Cumming Publishing Co. Palo Alto, California, USA.
10. Chapman, J.L. and Reiss, M.J. 1995. Ecology: Principles and Applications. Cambridge University Press.
11. Hussain F. 1989. Field and Laboratory Manual of Plant Ecology. National Academy of Higher Education, Islamabad.
12. Hussain, S.S. 1989. Pakistan Manual of Plant Ecology; National Book Foundation, Islamabad.
13. Larcher, W. 2003 Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functions Groups – Springer Verlag.
14. Krebs, C. J. 1997. Ecology. Harper and Row Publishers.
15. Smith, R. L. 1996. Ecology and Field Biology. Addison Wesley Longman, Inc., New York.
16. Smith, R. L. 1998. Elements of Ecology. Harper and Row Publishers, New York.
17. Smith, R. L. 2004. Ecology and field biology. Addison Wesley Longman, Inc., New York.
18. Subrahmanyam, N.S. and Sambamurthy, A.V.S.S. 2000. Ecology. Narosa Publishing House, New Delhi.
19. Townsend, C.R., Harper, J.L. and Begon, M.E. 2002. Essentials of Ecology. Blackwell Scientific Publications, UK.
20. Odum, E.P. 1985. Basic Ecology. W.B. Saunders.

Journals / Periodicals: Plant Physiology, Journal of Ecology

Title of the Course: Bot-403 Biodiversity and Conservation:

Credit Hours: 4(3+1)

Prerequisites: Bot-301, 302, 401, 402

Specific objectives of course: To familiarize the students with the diversity of nature. Importance of biodiversity for survival and proper functioning of ecosystems.

Course outline:

1. Definition of biodiversity as defined in the convention of biological diversity (CBD).
2. Introduction of species on each other for their survival.
3. Extent of known and estimated biodiversity of earth.
4. Measuring biodiversity: Alpha, Beta, and Gamma diversity, Systematic diversity, functional diversity, taxic diversity.
5. Ecological services, indirect value of ecosystem by virtue of their ecological functions, direct value of ecosystem (i.e. Utility of living resources).
6. Sustainable and unsustainable use of ecosystem resources, consequences of unsustainable use, ecosystem degradation, extinct species, desertification and deforestation.
7. Biodiversity Hot spots of the world.
8. International treaties/agreements regarding Biodiversity and conservation; CBD, CITES, Ramsar.
9. IUCN categorised protected areas in Pakistan.
10. Environmental Impact Assessment.
11. Use of herbarium and Botanical Garden in biodiversity and conservation.

Lab outline:

- 1 Inventory of plant biodiversity in various habitats.
- 2 Field survey for baseline studies and Impact Assessment.
- 3 Identification of wild plant species used by local communities in different ecosystems.

Recommended Books:

1. Heywood, V. (ed.). 1995. *Global Biodiversity Assessment*. Published for the United Nations Environment Programme. Cambridge University Press, Cambridge, UK.
2. Falk, D.A. & Holsinger, K.E. 1991. *Genetics and Conservation of Rare Plants*. Center for Plant Conservation. Oxford University Press, Oxford, UK.
3. Frankel, O.H., Brown, A.H.D. & Burdon, J.J. 1995. *The Conservation of Plant Biodiversity*. Cambridge University Press, Cambridge, UK.
4. IUCN. 1994. *IUCN Red List Categories*. As Approved by the IUCN Council. IUCN.
5. Leadlay, E. and Jury, S. 2006 *Taxonomy and Plant Conservation*. CUP.
6. Bush, M.B. 1997 *Ecology of a changing Planet*. Prentice hall. New Jersey.

7. French, H. 2000 Vanishing Borders- protecting the Planet in the age of globalization. W.W. Norton & Co
8. Swanson, T. 2005 Global Action for Biodiversity. Earth Scan Publication Ltd.
9. Taylor, P. 2005 Beyond Conservation. Earth Scan Publication Ltd.

Journals /Periodicals

Systematics and Biodiversity
Biological Conservation.

3rd Year 5th Semester

Title of the Course:	BOT-502	Bacteriology and Virology
Credit Hours:	3(2+1)	
Prerequisites:	Bot. 301, 302, 401, 402, 501	

Specific objectives of course: To understand the morphology, structure and economic importance of Viruses and Bacteria

Course outline:

a) Viruses

1. General features of viruses, viral architecture, classification, dissemination and replication of single and double – stranded DNA/RNA viruses.
2. Plant viral taxonomy.
3. Virus biology and virus transmission.
4. Molecular biology of plant virus transmission.
5. Symptomatology of virus-infected plants: (External and Internal symptoms).
6. Metabolism of virus-infected plants.
7. Resistance to viral infection.
8. Methods in molecular virology.

a) Bacteria

1. History, characteristics and classification.
2. Evolutionary tendencies in Monera (Bacteria, actinomycetes and cyanobacteria)
3. Morphology, genetic recombination, locomotion and reproduction in bacteria
4. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation)
5. Importance of bacteria with special reference to application in various modern sciences specially agriculture, biotechnology and genetic engineering.

Lab outline:

a) Viruses

Observation of symptoms of some viral infected plant specimens.

b) Bacteria, Actinomycetes and Cyanobacteria

1. Methods of sterilization of glassware and media etc.
2. Preparation of nutrient medium and inoculation.
3. Preparation of slides for the study of various forms, capsule/slime layer, spores, flagella and Gram-staining.
4. Growth of bacteria, subculturing and identification of bacteria on morphological and biochemical basis (using available techniques).
5. Microscopic study of representative genera of Actinomycetes and Cyanobacteria from fresh collections and prepared slides.

Recommended Books:

1. Black, J.G. 2005 Microbiology - Principles and Exploration, John Wiley and Sons, Inc.
2. Prescott, L.M., Harley, J.P. and Klein, D.A. 2005. Microbiology McGraw Hill Companies, Inc.
3. Arora, D.R. 2004. Textbook of Microbiology, CBS Publishers and Distributors, New Delhi.
4. Ross F.C. 1995. Fundamentals of Microbiology. John Willey Co. New York.
5. Khan, J. A. and Dijkstra J. Plant Viruses as Molecular Pathogens, The Haworth Press, Inc.
6. Hull R. Matthews, 2004, Plant Virology, Academic Press.
7. Tortora, G.J. ; Funke, B.R. and Case C.L. , 2004, Microbiology. Pearson Education.

Journals/Periodicals: World Journal of Microbiology & Biotechnology, Current Microbiology, Journal of Industrial Microbiology and Biotechnology, Journal of General Virology, Journal of Virology

Title of the Course: Bot- 50 Phycology And Bryology

Credit Hours: 3(2+1)

Prerequisites: Bot. 301, 302, 401, 402, 501

Specific objectives of course: To understand the classification, morphology and economic importance of Algae and Bryophytes

Course Outline:

a) Phycology

Introduction, general account, evolution, classification, biochemistry, ecology and economic importance of the following divisions of algae: Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.

b) Bryology:

Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Hepaticopsida, Anthocerosida and Bryopsida.

Lab Outline:

a) Phycology:

- i. Collection of fresh water and marine algae.
- ii. Identification of benthic and planktonic algae
- iii. Section cutting of thaloid algae
- iv. Preparation of temporary slides
- v. Use of camera lucida/micrographs.

b) Bryology

Study of the following genera:
Pellia, *Porella*, *Anthoceros* and *Polytrichum*.

Recommended Books:

1. Bold, H. C. and M.J. Wynne 1985. Introduction to Algae: structure and reproduction. Prentice Hall Inc. Engle Wood Cliffs
2. Lee. R.E. 1999. Phycology. Cambridge University Press, U.K.
3. Dawson, E.Y., Halt. 1966. Marine Botany. Reinhart and Winstan, New York.
4. Chapman, V.J. and D.J. Chapman. 1983. Sea weed and their uses. McMillan and Co. Ltd. London.
5. Vashishta. B. R. 1991. Botany for degree students. Bryophytes 8th ed. S. Chand and Co. Ltd. Delhi.
6. Schofield, W.B. 1985. Introduction to Bryology. Macmillan Publishing Co. London.
7. Hussain, F. and I. Ilahi. 2004. A text book of Botany. Department of Botany, University of Peshawar.

Journals / Periodicals: Pakistan Journal of Botany, International Journal of Phycology and Phycochemistry, Bryology, Phycology.

Title of the Course: Bot-504 Mycology and Plant Pathology

Credit Hours: 3(2+1)

Prerequisites: Bot. 301, 302, 401, 402, 501

Specific Objectives of course: To introduce the students to Mycology and Diseases caused by Fungi.

Course Outline:

a) Mycology

1. Introduction: General characters of fungi, Thallus, cell structure and ultrastructure of fungi.
2. Reproduction: Asexual and sexual reproduction and reproduction structures, life cycle, haploid, heterokaryotic and diploid states.
3. Fungal Systematics: Classification of fungi into phyla with suitable examples to illustrate somatic structures, life cycle and reproduction of Myxomycota, Chytridiomycota, Zygomycota (Mucrales) Oomycota (Peronosporales), Ascomycota (Erysiphales, Pezizales), Basidiomycota (Agaricales, Polyporales, Uredinales, Ustilaginales) and Deuteromycetes.

4. Symbiotic relationships of fungi with other organisms (lichens and mycorrhiza) and their significance.
5. Importance of fungi in human affairs with special reference to Industry and Agriculture

b) Pathology

1. Introduction and classification of plant diseases.
2. Symptoms, causes and development of plant diseases
3. Loss assessment and disease control
4. Epidemiology and disease forecast
5. Important diseases of crop plants and fruit trees in Pakistan caused by fungi, e.g. damping off, mildews, rusts, smuts, shisham dieback etc.

Lab Outline:

a) Mycology

General characters and morphology of fungi. Study of unicellular and mycelial forms with septate and aseptate hyphae. Distinguishing characters of different phyla: study of suitable examples. Study of asexual and sexual reproductive structures in different groups of fungi. Study of some common examples of saprophytic, parasitic and air-borne fungi belonging to different phyla.

b) Pathology

Identification of major plant pathogens under lab and field conditions, cultural studies of some important plant pathogenic fungi, application of Koch's postulates for confirmation of pathogenicity. Demonstration of control measures through chemotherapeutants.

Recommended Books:

1. Agrios, G.N., 2005. Plant Pathology, Academic Press, London.
2. Ahmad, I. and Bhutta, A.R., 2004. Textbook of Introductory Plant Pathology. Book Foundation, Pakistan.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M., 1996. Introductory Mycology, 4th ed. John Wiley & Sons.
4. Khan, A.G. and Usman, R., 2005. Laboratory Manual in Mycology and Plant Pathology. Botany Department Arid Agriculture University, Rawalpindi.
5. Mehrotra, R.S. and Aneja, K.R., 1990. An Introduction to Mycology. Wiley and Eastern Ltd., New Delhi, India.

6. Moore-Landecker, E., 1996. Fundamentals of Fungi. 4th edn. Prentice Hall Inc., New Jersey, USA.
7. Trigiano, R.N., Windham, M.T. and Windham, A.S., 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

Journals / Periodicals: Pakistan Journal of Botany, Mycotoxin, Mycopath, Phytopathology, Australasian Journal of Plant pathology, Asian Journal of Plant Pathology, Annual Review of Plant Pathology

Title of the Course: Bot-505 Diversity of Vascular Plants

Credit Hours: 3(2+1)

Prerequisites: Bot. 301, 302, 401, 402, 501

Specific Objectives of course: To enable the students to understand and appreciate the biology and evolution of plant architecture

Course Outline:

a) Pteridophytes

Introduction, origin, history, features and a generalized life cycle. Methods of fossilization, types of fossils, geological time scale and importance of paleobotany. First vascular plant - Rhyniophyta e.g. *Cooksonia*

General characters, classification, affinities and comparative account of evolutionary trends of the following phyla: Psilopsida (*Psilotum*), Lycopsidea (*Lycopodium*, *Selaginella*), Sphenopsida (*Equisetum*), Pteropsida (*Ophioglossum*, *Dryopteris* and *Azolla/Marsilea*).

b) Origin and Evolution of seed habit.

c) Gymnosperms:

Geological history, origin, distribution, morphology, anatomy, classification and affinities of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales and Gnetales. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms. An introduction to the Gondwana flora of world.

d) Angiosperms:

Origin, general characteristics, Importance, and life cycle of angiosperms

e) Palynology:

1. An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey and oil and gas exploration.
2. Basic information about the nomenclature, morphology and classification of living and fossil pollen and spores.

Lab Outline:

1. To study the morphological and reproductive features of available genera.
2. Study trips to different parts of Pakistan for the collection and identification of important pteridophytes, gymnosperms and angiosperms.

Recommended Books:

1. Beck, C.B. 1992. Origin and Evolution of Gymnosperms. Vol-1&II, Columbia University Press, New York,
2. Foster, A.S. and Gifford, E. M. Jr. 1998. Comparative Morphology of Vascular Plants. W. H. Freeman and Co.
3. Jones, D. 1983. Cycadales of the World, Washington, DC.
4. Mauseth, J.D. 1998. An Introduction to Plant Biology, Multimedia Enhanced, Jones and Bartlett Pub. UK.
5. Moore, R.c., W.d. Clarke and Vodopich, D.S. 1998. Botany McGraw Hill Company, USA
6. Raven, P.H. Evert, R.E. and Eichhorn, S.E. 1999. Biology of Plants, W.H. Freeman and Company Worth Publishers.
7. Ray, P.M. Steeves, T.A. and Fultz, T.A. 1998. Botany Saunders College Publishing, USA.
8. Taylor, T.N. and Taylor, E.D. 2000. The Biology and Evolution of Fossil Plants, Prentice Hall.

9. Stewart, W. N. and Rothwell, G.W. 1993. Paleobotany and the Evolution of Plants, University Press, Cambridge.
10. Faegri, K., P.E. Kaland & K. Krzywinski 1989. Text Book of Pollen Analysis, Jhon Wiley & Sons. N.Y.

Journals / Periodicals: Pakistan Journal of Botany, New Phytologist, Review of Palaeobotany & Palynology, Palaeontographica, Palaeobotanist

Title of the Course: Bot-506 Plant Systematics

Credit Hours: 3(2+1)

Prerequisites:

Specific Objectives of course: To know floral composition/ system of classification focusing on identification, classification, description nomenclature and flora writings, monographs.

Course Outline:

1. Introduction: Importance and relationship with other sciences, Phases of plant taxonomy. Origin and radiation of angiosperm, their probable ancestors, when, where and how did the angiosperms evolve; the earliest fossil records of angiosperms.
2. Concept of Species : What is a species? Taxonomic species, Biological species, Micro and macro species, Species aggregate., Infra specific categories.
3. Speciation: Mechanism of speciation, Mutation and hybridization Geographical isolation, Reproductive isolation, Gradual and abrupt.
4. Variation : Types of variation, Continuous and discontinuous variation, Clinal variation.
5. Systematics and Genecology / Biosystematics: Introduction and importance, Methodology of conducting biosystematics studies, Various biosystematics categories such as ecophene, ecotype, ecospecies, coenospecies and comparium.

6. Taxonomic Evidence: Importance and types of taxonomic evidences: anatomical, cytological, chemical, molecular, palynological, geographical and embryological.
7. Nomenclature : Important rules of botanical nomenclature including effective and valid publication, typification, principles of priority and its limitations, author citation, rank of main taxonomic categories, conditions for rejecting names.
8. Classification: Why classification is necessary? Importance of predictive value. Brief history, Different systems of classification with at least one example of each (Linnaeus, Bentham and Hooker, Engler and Prantl, Bessey, Cronquist, Takhtajan, and Dahlgren).
9. Brief introduction of Numerical taxonomy.
10. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families of angiosperm:
 1. Apiaceae (Umbelliferae)
 2. Arecaceae (Palmae)
 3. Asclepiadaceae
 4. Asteraceae (Compositae)
 5. Boraginaceae
 6. Brassicaceae (Cruciferae)
 7. Cannaceae
 8. Capparidaceae
 9. Caryophyllaceae
 10. Casuarinaceae
 11. Chenopodiaceae
 12. Convolvulaceae
 13. Cucurbitaceae
 14. Cyperaceae
 15. Euphorbiaceae
 16. Fabaceae (Leguminosae)
 17. Juncaceae
 18. Lamiaceae (Labiatae)
 19. Liliaceae
 20. Magnoliaceae
 21. Malvaceae
 22. Myrtaceae
 23. Orchidaceae
 24. Papaveraceae
 25. Poaceae (Gramineae)
 26. Ranunculaceae

- 27. Rosaceae
- 28. Salicaceae
- 29. Scrophulariaceae
- 30. Solanaceae
- 31. Trochodendraceae
- 32. Winteraceae

Lab Outline:

1. Technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan
2. Preparation of indented and bracketed types of keys
3. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters.
4. Study of variation pattern in different taxa.
5. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination
6. Field trips shall be undertaken to study and collect plants from different ecological zones of Pakistan.

Recommended Books:

1. Ali, S.I. and Nasir, Y. 1990-92. Flora of Pakistan. Karachi Univ. Press, Karachi
2. Ali, S.I. and Qaiser, M. 1992-2007 -todate. Flora of Pakistan. Karachi Univ. Press, Karachi.
3. Greuter, W., McNeill, J., Barrie, F.R., Burdet, H. M., Demoulin, V., Filguerras, T.S., Nicolson, D.H. Silva, P.C., Skog, J.E., Trehane, P., Turland, N.J. & Hawksworth, D.L., (eds.) 2000. International code of botanical nomenclature (Saint Louis Code) adopted by the Sixteenth International botanical congress St. Louis Missouri, July –August 1999. Koeltz, Konigstein. (Regnum Veg.138.)
4. Davis, P.H. & Heywood, V.H. 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd, London
5. Ingrouille, M. 1992. Diversity and Evolution of Land Plants, Chapman & Hall. London
6. Nasir, E. & Ali, S.I. 1970-89. Flora of Pakistan. Karachi Univ. Press, Karachi.
7. Stace, C. (1992). Plant Taxonomy and Biosystematics, Edward Arnold..
8. Takhtajan, A. (1986). Flowering Plant: Origin and Dispersal, Oliver and Boyd, Edinburgh
9. Jones, S. B. and Luchsinger, A.E. 1987. Plant Systematics. McGraw Hill, Inc. New York.

10. Naik, V.N. 2005. Taxonomy of Angiosperms. Tata McGraw Hill Publishing Company, New Delhi.
11. Stussy, T.F. 1990. Plant Taxonomy, Columbia University Press, USA.
12. Jeffrey C. 1980. An Introduction to Plant Taxonomy. Cambridge University Press.UK
13. Levin, D.A. 2000. The Origin, Expansion and Demise of Plant Species. Oxford University Press.
14. Sivarajan V.V and N.K.P Robson 1991 Introduction to the Principles of Plant Taxonomy.
15. Radford, A.E., W.C. Dickison, J.R. Massey, and C. R. Bell. 1998 Vascular Plant Systematic. Harper and Row, New York.
16. Leadlay, E. and Stephen 2006. Taxonomy and Plant Conservation.
17. Rajput, M. T., S. Saliha and K. M. Khan. 1996 Plant Taxonomy. Nasim Book Depot Hyderabad.
18. Heywood V.H. 1978. Flowering Plants of the World. Oxford University Press.
19. Simpson, M.G. 2006. Plant Systematics. Elsevier Academic Press.
20. Soltis, D.E. P.S. Soltis, P.K Endress, and M.W. Chase, 2005. Phylogeny & evolution of angiosperms. Sinauers associates, Inc. Publishers.
21. Pullaiah, T. 2007 Taxonomy of Angiosperms 3rd Ed. Regency Publication, New Delhi.

Journals / Periodicals: Pakistan Journal Botany, Flora of Pakistan, Taxon, Botanical Journal of the Linnean Society

6th Semester

Title of the course: Bot-507 Anatomy of Vascular Plants

Credit hours: 3(2+1)

Prerequisites: Bot. 301, 302, 401, 402, 501

Specific objectives of course: To provide the students understanding about anatomical features of vascular plants

Course Outline:

1. The plant body and its development: fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body.
2. Meristematic tissues: classification, cytohistological characteristics, initials and their derivatives.
3. Apical meristem: Delimitation, different growth zones, evolution of the concept of apical organization. Shoot and root apices.
4. Leaf: types, origin, internal organization, development of different tissues with special reference to mesophyll, venation, bundle-sheaths and bundle-sheath extensions. Enlargement of epidermal cells.
5. Vascular cambium: Origin, structure, storied and non-storied cell types, types of divisions: additive and multiplicative; cytoplasmic characteristics, seasonal activity and its role in the secondary growth of root and stem. Abnormal secondary growth.
6. Origin, structure, development, functional and evolutionary specialization of the following tissues: Epidermis and epidermal emergences, Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem with special emphasis on different types of woods, Periderm.
7. Secretory tissues: Laticifers (classification, distribution, development, structural characteristics, functions) and Resin Canals.
8. Anatomy of reproductive parts:
 - Flower
 - Seed
 - Fruit
9. Economic aspects of applied plant anatomy
10. Anatomical adaptations
11. Molecular markers in tree species used for wood identification.

Lab outline:

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures.
2. Study of abnormal/unusual secondary growth.
3. Peel and ground sectioning and maceration of fossil material.
4. Comparative study of wood structure of Gymnosperms and Angiosperms with the help of prepared slides.

Recommended Books:

1. Dickison, W.C. 2000. Integrative plant anatomy. Academic Press, U.K.
2. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
3. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
4. Metcalf, C.R. and Chalk, L. 1950. Anatomy of the Dicotyledons. Clarendon Press. Oxford.
5. Anon. Manual of Microscopic Analysis of Feeding Stuffs. The American Association of feed Microscopists.
6. Vaughan, J.G. 1990. The structure and Utilization of Oil Seeds. Chapman and Hall Ltd. London.
7. Metcalfe, C.R. 1960. Anatomy of the Monocotyledons. Gramineae. Clarendon Press, Oxford.
8. Metcalfe, C.R. 1971. Anatomy of the Monocotyledons.V. Cyperaceae. Clarendon Press, Oxford.
9. Cutler, D.F. 1969. Anatomy of the Monocotyledons. IV. Juncales. Clarendon Press, Oxford.
10. Cutler, D.F. 1978. Applied Plant Anatomy. Longman Group Ltd. England
11. Raymond, E.S. and E. Eichhorn. 2005. Esau's Plant Anatomy; Meristematic cells and tissues of plant body. John Willey Sons.
12. Eames, A.J. and L.H. Mac Daniels. 2002. An introduction to Plant Anatomy. Tat Mac-Graw Hill Publishing Company Limited, New Delhi.

Journals / Periodicals: Pakistan Journal of Botany

Title of the Course: Bot-508 Genetics -I

Credit Hours: 3(2+1)

Prerequisites: Bot. 301, 302, 401, 402, 501

Specific Objectives of course: To understand the nature and function of genetic material

Course Outline:

1. Extensions of Mendelian Analysis : Variations on dominance, multiple alleles, lethal alleles, several genes affecting the same character, penetrance and expressivity.

2. Linkage I: Basic Eukaryotic Chromosome Mapping : The discovery of linkage, recombination, linkage symbolism, linkage of genes on the X chromosome, linkage maps, three-point testcross, interference, linkage mapping by recombination in humans,
3. Linkage II: Special Eukaryotic Chromosome Mapping Techniques : Accurate calculation of large map distances, analysis of single meioses, mitotic segregation and recombination, mapping human chromosomes.
4. Gene Mutation :Somatic versus germinal mutation, mutant types, the occurrence of mutations, mutation and cancer, mutagens in genetic disorder, mutation breeding. Evolutionary significance of mutation.
5. Recombination in Bacteria and their Viruses : Bacterial chromosome, bacterial conjugation, bacterial recombination and mapping the *E.coli* chromosome, bacterial transformation, bacteriophage genetics, transduction, mapping of bacterial chromosomes, bacterial gene transfer.
6. The Structure of DNA : DNA: The genetic material, DNA replication in eukaryotes, DNA and the gene.
7. The Nature of the Gene : How genes work, gene- protein relationships, genetic observations explained by enzyme structure, genetic fine structure, mutational sites, complementation.
8. DNA Function : Transcription, translation, the genetic code, protein synthesis, universality of genetic information transfer, eukaryotic RNA.
9. The Extranuclear Genome : Variegation in leaves of higher plants, cytoplasmic inheritance in fungi, extranuclear genes in chlamydomonas, mitochondrial genes in yeast, extragenomic plasmids in eukaryotes.
10. Developmental Genetics:Gene Regulation and Differentiation, Crown gall disease in plants, cancer as a developmental genetic disease.
11. Population Genetics: Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

Lab Outline:

1. Numerical problems

- a) Arrangement of genetic material:
 - i. Linkage and recombination.
 - ii. Gene mapping in diploid.
 - iii. Recombination in Fungi.
 - iv. Recombination in bacteria.
 - v. Recombination in viruses.
- b) Population Genetics:
 - i. Gene frequencies and equilibrium.
 - ii. Changes in gene frequencies,

2. Blood group and Rh-factor

3. Drosophila

- i. Culture technique
- ii. Salivary gland chromosome

4. Fungal genetics

Sacchromyces culture techniques and study.

5. Studies on variation in maize ear size and colour variation

6. Bacterial Genetics.

- i. Bacterial cultural techniques, Gram staining (E. coli, B. subtilis)
- ii. Transformation.
- ii. Conjugation.

Recommended Books:

1. Gelvin, S.B. 2000. Plant Molecular Biology Manual. Kluwer Academic Publishers.
2. Pierca, B.A. 2005. Genetics. A conceptual approach, W. H. Freeman and Company, New York.
3. Synder, L, and Champness, W. 2004. Molecular Genetics of Bacteria. ASM Press, Washington D.C.
4. Klug, W.S. and Cummings, M.R. 1997. Concepts of Genetics, Prentice Hall International Inc.
5. Roth Well, N.V. 1997. Understanding Genetics, second edition, Oxford University Press Inc.
8. Gardner, E.J., 2004. Principles of Genetics, John Willey and Sons, New York.
6. Ringo J, 2004. Fundamental Genetics, Cambridge University Press.

7. Griffiths A.J.F: Wessler, S.R; Lewontin, R.C, Gelbart, W.M; Suzuki, D.T. and Miller, J.H., 2005, Introduction to Genetic Analysis, W.H. Freeman and Company.
8. Snyder, L and Champness W, 2003, Molecular Genetics of Bacteria, ASM Press.
- 10 Hartl, D.L. and Jones, E.W. 2005, Genetics - Analysis of Genes and Genomes, Jones and Bartlett Publishers. Sudbary, USA.
- 11 Hedrick, P.W. 2005. Genetics of Population. Jones and Bartlett Publisher, Sudbury, USA.

Journals / Periodicals: J. Genetics, Theoretical and Applied Genetics, Cytologia, Chromosoma, Genome

Title of the Course: Bot-509 Plant Biochemistry-I

Credit Hours: 3(2+1)

Prerequisites: F.Sc. Biology/ Chemistry

Specific Objectives of course: To elucidate the structure and role of primary metabolites in plants

Course Outline:

Carbohydrates: Occurrence and classification. A general account of ribose, deoxyribose, xylulose, xylose, D-glucose, D-galactose, D-mannose, cellobiose, sucrose, maltose, trehalose, pentosans, fructosans, starch, cellulose, hemicellulose, amino sugars, derived acids and alcohols, glycosides, mucilages, pectins and lignins.

Lipids: Occurrence, classification. Structure and chemical properties of fatty acids, triglycerides, phospholipids, glycolipids, sulpholipids, waxes and sterols.

Proteins: Amino acids and their structure. Electro chemical properties and reactions of amino acids. Classification of proteins. Primary, secondary, tertiary and quaternary structure of proteins. Protein targeting. Protein folding and unfolding. Transport, storage, regulatory and receptor proteins. Protein purification. Protein sequencing. Biological role.

Nucleic Acids: General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. Chemical synthesis of oligonucleotides and DNA sequencing. DNA restriction enzymes. Properties of DNA polymerase I, II and III.

Enzymes: Nature and functions, I.U.E. classification with examples of typical groups. Isozymes, ribozymes, abzymes. Enzyme specificity. Enzyme kinetics. Nature of active site and mode of action. Allosteric enzymes and feedback mechanism.

Lab Outline:

1. Solutions, acids and bases. Electrolytes, non-electrolytes, buffers, pH. Chemical bonds.
2. To determine the R_f value of monosaccharides on a paper Chromatogram.
3. To estimate the amount of reducing and non-reducing sugars in plant material titrimetrically/spectrophotometrically.
4. To determine the saponification number of fats.
5. To extract and estimate oil from plant material using soxhlet apparatus.
6. Analysis of various lipids by TLC methods.
7. To estimate soluble proteins by Biuret or Lowry or Dye-binding method.
8. To estimate the amount of total Nitrogen in plant material by Kjeldahl's method.
9. To determine the R_f value of amino acids on a paper chromatogram.
10. Extraction of Nucleic acids from plant material and their estimation by UV absorption or colour reactions.
11. To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.
12. To determine the PK_a and isoelectric point of an amino acid.

Recommended Books:

1. Conn E E. and Stumpf P.K., 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
2. Lehninger, A L. 1998. Principles of Biochemistry. Worth Publishers Inc.
3. Voet, D., Voet J.G. and Pratt, C.W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.

4. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
5. Smith, E. L., Hill, R L, Lehman, R I., Lefkowitz, R J. Handler and Abraham. 2003, Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
6. Zubay G,..2003, Biochemistry, MacMillan Publishing Co., New York.
7. Chesworth,. J.M., Strichbury T. and Scaife., J. R. 1998. An introduction to agricultural biochemistry. Chapman and Hall, London.
8. Mckee, T. and Mckee, J.R. 1999. Biochemistry – An Introduction. WCB/McGraw-Hill, New York, Boston, USA.
9. Lea, P.J.. and Leegood, R.C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
10. Abdes, R.H. Frey, P.A. and Jencks W.P. 2004, Biochemistry, Jones and Bartlet, London.
11. Goodwin T.W. and Mercer, E.I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
12. Heldt, H-W. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
13. Bowsher, C. 2008. Plant Biochemistry. Campbell, M.K. and F. Shawn. 2008. Biochemistry 6th Edition.

Journals / Periodicals: Plant Physiology & Biochemistry, Annual Review of Biochemistry, Biochemistry Journal, Critical Review in Biochemistry and Molecular Biology

Title of the Course: Bot-510 Plant Ecology I

Credit Hours: 3(2+1)

Prerequisites: Bot. 301, 302, 401, 402, 501

Specific Objectives of course: To understand the role and interaction of plants with their environment

Course Outline:

1. Introduction: history and recent developments in ecology
2. Soil: Nature and properties of soil (Physical and Chemical). Water in the soil-plant-atmosphere continuum. The ionic

environment and plant ionic relations, Nutrient cycling. Physiology and ecology of N, S, P and K nutrition. Heavy metals (brief description), Salt and drought stress and osmoregulation. Soil erosion

3. Light and temperature: Nature of light, Factors affecting the variation in light and temperature, Responses of plants to light and temperature, Adaptation to temperature extremes,
4. Carbon dioxide: Stomatal responses, water loss and CO₂-assimilation rates of plants in contrasting environments. Ecophysiological effects of changing atmospheric CO₂ concentration. Functional significance of different pathways of CO₂ fixation. Productivity: response of photosynthesis to environmental factors, C and N balance
5. Water: Water as an environmental factor, Role of water in the growth, adaptation and distribution of plants, Water status in soil., Water and stomatal regulation, Transpiration of leaves and canopies.
6. Oxygen deficiency: Energy metabolism of plants under oxygen deficiency, Morpho-anatomical changes during oxygen deficiency, Post-anoxic stress
7. Wind as an ecological factor.
8. Fire as an ecological factor.

Lab Outline:

1. Determination of physico-chemical properties of soil and water.
2. Measurements of light and temperature under different ecological conditions.
3. Measurements of wind velocity.
4. Measurement of CO₂ and O₂ concentration of air and water.
5. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem pressure potential, leaf area and rate of CO₂ exchange in plants in relation to various environmental conditions.

Recommended Books:

1. Schultz, J. C. 2005. Plant Ecology, Springer-Verlag

2. Bazzaz, F.A. 2004. Plants in Changing Environments: Linking Physiological, Population, and Community Ecology, Cambridge University Press
3. Chapin, F.S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag
4. Lambers, H. et al. 2002. Plant Physiological Ecology, Springer-Verlag
5. Larcher, W. 2003., Physiological Plant Ecology: Ecophysiology and Stress Physiology of Function Groups - Springer-Verlag
6. Nobel, P.S 1999, Physico-chemical and Environmental Plant Physiology, Academic Press.
7. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiological Ecology.
8. Smith, R. L. 2004. Ecology and field Biology. Addison Wesley Longman, Inc., New York.
9. Barbour, M.G., Burke, J.H and Pitts, W.D. 2004 Terrestrial Plant Ecology, The Benjamin, Cumming Publishing C. Palo Alto, California, USA.
10. Smith R.L. 1998 Elements of Ecology. Harper & Row Publishing.
11. Townsend. C.R. Begon. M and J.L Harper. 2002 Essentials of ecology. Blackwell Publishing.
12. Gurevitch. J. Scheiner, S.M. and G.A Fox. 2006 The Ecology of Plants\ Sinaur Asssoicate Inc.
13. Hussain. F. 1989 Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education, Islamabad.
14. Hussain. S.S. 1989 Pakistan Manual of Plant Ecology. National Book Foundation Islamabad.
15. More. P.D. and Chapman S.B. 1986 Methods in Plant Ecology, Blackwell Scientific Publication Oxford.

Journals / Periodicals: Pakistan Journal of Botany, Journal of Ecology, Journal of Applied Ecology, Ecology, Journal of Arid Environment

Title of the Course: Bot-511 Plant Physiology-I

Credit Hours: 3(2+1)

Prerequisites: F.Sc. Biology, Botany

Specific Objectives of course: To provide comprehensive knowledge on some vital functions and mechanisms of plants

Course Outline:

1. **Photosynthesis:** History of photosynthesis. Nature and units of light. Determination of oxygenic and anoxygenic photosynthesis. Ultrastructure of thylakoid vesicle. Various pigments and photosynthetic activity. Ultrastructure and composition of photosystem-I and II. Absorption and action spectra of different pigments. Mechanism of photosynthesis - light absorption, charge separation or oxidation of water (water oxidizing clock), electron and proton transport through thylakoid protein-pigment complexes. Photophosphorylation and its mechanism. CO₂ reduction (dark reactions) - C₃ pathway and Photorespiration, Regulation of C₃ pathway, C₄ pathway and its different forms, C₃-C₄ intermediates, CAM pathway. Methods of measurement of photosynthesis.
2. **Respiration:** Synthesis of hexose sugars from reserve carbohydrates. Mechanism of respiration- Glycolysis, Differences between cytosolic and chloroplastidic glycolysis, Oxidative decarboxylation, Krebs cycle, Regulation of glycolysis and Krebs cycle, Electron transport and oxidative phosphorylation. Aerobic and anaerobic respiration. Energetics of respiration. Pentose phosphate pathway. Glyoxylate cycle. Cyanide resistant respiration.
3. **Translocation of Food:** Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.
4. **Leaves and Atmosphere:** Gaseous exchange, mechanism of stomatal regulation. Factors affecting stomatal regulation.
5. **Assimilation of Nitrogen, Sulphur and Phosphorus:** The nitrogen cycle. Nitrogen fixation. Pathways of assimilation of nitrate and ammonium ions. Assimilation of sulphur and phosphorus.

Lab Outline:

1. To determine the volume of CO₂ evolved during respiration by plant material.
2. To determine the amount of O₂ used by respiring water plant by Winkler Method.
3. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
4. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties.
5. To categorize C₃ and C₄ plants through their anatomical and physiological characters.
6. To regulate stomatal opening by light of different colours and pH.

Recommended Books:

1. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U.K.
2. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
3. Fitter, A. and Hay, R.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.
4. Heldt, H-W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
5. Ihsan Illahi, 1991. Plant Growth, UGC Press, Islamabad.
6. Ihsan Illahi, 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
7. Nobel, P.S. 1999. Physicochemical and Environmental Plant Physiology. Academic Press, UK.
8. Press, M.C., Barker, M.G., and Scholes, J.D. 2000. Physiological Plant Ecology, British Ecological Society Symposium, Volume 39, Blackwell Science, UK.
9. Salisbury F.B. and Ross C.B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
10. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinauers Publ. Co. Inc. Calif.
11. W.B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.
12. Epstein, E. and Bloom, A.J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
13. Kirkham, M.B. 2004. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam, Netherlands.

14. Barton, w. 2007. Recent Advances in Plant Physiology.

Journals / Periodicals: Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology

Title of the Course: Bot-512 Research Methodology

Credit Hours: 1(1+0)

Prerequisites:

Specific objectives of course: To enable the students to know the theoretical aspects of planning research, handling, presentation of data, writing and submission of research papers and thesis

Course Outline:

What is science, philosophy and theory, how to do science. Questions, hypothesis, their types, experimentation, validation, theories and laws. Research Methods (planning research, various methods, analyzing results, giving reports, etc.) research process including: formulating research questions; sampling (probability and nonprobability); measurement (surveys, scaling, qualitative, unobtrusive); research design (experimental and quasi-experimental); data analysis; and, writing the research paper, the major theoretical and philosophical underpinnings of research including: the idea of validity in research; reliability of measures; and ethics

Recommended Books:

1. Shank, G. D. 2002. Qualitative research : a personal skills approach. Upper Saddle River, N.J.Columbus, Ohio: Prentice Hall;Merrill/Prentice Hall.
2. Brizuela, B. M. 2000. Acts of inquiry in qualitative research. Cambridge, MA: Harvard Educational Review
3. Shank, G. D. 2001, Qualitative Research: A Personal Skills Approach

4. Paul Leedy, 2004, Practical Research : Planning and Design (8th, Edition), Jeanne Ellis Ormrod

**4th YEAR
7th Semester**

Title of the Course: Bot-601 Molecular biology

Credit Hours: 3(2+1)

Prerequisites: Bot. 508, 509, 511

Specific Objectives of course: To disseminate the knowledge of molecular basis of life

Course Outline:

1. Nucleic Acids: DNA-circular and superhelical DNA. Renaturation, hybridization, sequencing of nucleic acids, synthesis of DNA
2. Proteins: Basic features of protein molecules. Folding of polypeptide chain, α -helical and β -secondary structures. Protein purification and sequencing.
3. Transcription: Enzymatic synthesis of RNA, transcriptional signals Translation: The genetic code. The Wobbling, polycistronic and monocistronic RNA. Overlapping genes.
4. Gene regulation in Eukaryotes: Differences in genetic organization and prokaryotes and eukaryotes. Regulation of transcription, initiation, regulation of RNA processing, regulation of nucleocytoplasmic mRNA transport, regulation of mRNA stability, regulation of translation, regulation of protein activity.
5. Plant Omics: Transcriptomics; DNA libraries, their construction, screening and application. Microarray of gene technology and its application in functional genomics.
6. Proteomics; structural and functional proteomics. Methods to study proteomics Metabolomics; methods to study metabolomics; importance and application of metabolomics.

7. Bioinformatics and computational biology. Levels, scope, potential and industrial application of bioinformatics and computational biology.

Lab Outline:

Following techniques will be used for the isolation and analysis of different components:

1. Extraction of RNA, DNA and proteins
2. Electrophoreses: One and two dimensional
3. Purification of proteins, RNA and DNA.
4. Amplification using PCR.
5. Northern, Western and Southern Blotting.

Recommended Books:

1. Cullis, C.A. 2004. Plant Genomics and Proteomics. Wiley-Liss, New York.
2. Gibson, G. and S.V. Muse, 2002. A Premier of Genome Science, Sinauer Associates Inc. Massachusetts.
3. Gilmartin, P.M. and C. Bowler. 2002. Molecular Plant Biology. Vol. 1 & 2. Oxford University Press, UK.
4. Lodish, H. et al., 2004. Molecular Cell Biology. 5th Edition. W.H. Freeman & Co., New York.
5. Malacinski, G. M. 2003. Essentials of Molecular Biology, 4th edition. Jones and Bartlett Publishers, Massachusetts.
6. Watson, J.D. et al. 2004. Molecular Biology of the Gene. Peason Education, Singapore.
7. Ignacimuthu, S. 2005. Basic bioinformatics. Narosa Publishing House, India.
8. Weaver, R.F. 2005. Molecular Biology. Mc|Graw Hill, St. Louis.

Title of the Course: Bot-602 Plant Biochemistry-II

Credit Hours: 3(2+1)

Prerequisites: Bot. 509

Specific Objectives of course: To explicit the fundamentals of metabolic energy, Metabolism and Plant constituents.

Course Outline:

1. Bioenergetics: Energy, laws about energy changes. Oxidation and reduction in living systems.
2. Metabolism:
 - i. Biosynthesis, degradation and regulation of sucrose and starch. Breakdown of fats with special reference to beta-oxidation and its energy balance. Biosynthesis of fats.
 - ii. Replication of DNA. Reverse transcription. Biosynthesis of DNA and RNA.
 - iii. Components of protein synthesis. Genetic code, protein synthesis: initiation, elongation and termination.
3. Alkaloids: Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Aflatoxins, their nature and role.
4. Terpenoids: Classification: monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis.
5. Vitamins: General properties and role in metabolism.

Lab Outline:

1. Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
2. Separation of nucleic acids by gel electrophoresis.
3. To estimate the amount of vitamin C in a plant organ (orange, apple juice).
4. To determine potential alkaloids in plants.
5. To estimate terpenoids in plants.

Recommended Books:

1. Conn E. E. and Stumpf, P.K. 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
2. Albert L. Lehninger, 1998. Principles of Biochemistry. Worth Publishers Inc.

3. Voet, D. Voet J.G. and Pratt, C.W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.
4. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
5. Smith; E L., Hill; R. L., Lehman; R. I., Lefkowitz, R J. and Abraham. H. Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
6. Zubay. G. 2003, Biochemistry, MacMillan Publishing Co., New York.
7. Chesworth,. J.M., Strichbury T. and Scaife, J. R. 1998. An introduction to agricultural biochemistry. Chapman and Hall, London.
8. Mckee, T. and Mckee, J.R. 1999. Biochemistry – An Introduction. WCB / McGraw-Hill, New York, Boston, USA.
9. Lea, P.J.. and Leegood, R.C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
10. Abides, R.H., Frey P.A. and Jencks, W.P. 1992. Biochemistry, Jones and Bartlet, London.
11. Goodwin T.W. and Mercer, E.I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
12. Heldt, H-W. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
13. Campbell, M.K. and F. Shawn. 2008. Biochemistry 6th Edition.

Journals / Periodicals: Plant Physiology & Biochemistry,
Annual Review of Biochemistry,
Biochemistry Journal, Critical Review in
Biochemistry and Molecular Biology

Title of the Course: Bot-603 Plant Ecology -II

Credit Hours: 3(2+1)

Prerequisites: Bot. 505 & 510

Specific Objectives of course: To provide comprehensive knowledge of population, community, ecosystem ecology and its relevance to mankind.

Course Outline:

- A. Population Ecology
 - 1. Population structure and plant demography.: Seed dispersal, Dormancy, Seed Bank, Seed dormancy, Recruitment, Demography
 - 2. Life history pattern and resource allocation : Density dependent and density independent factors, Resource allocation, Reproductive effort, Seed size vs seed weight, Population genetics, Evolution
- B. Community Ecology : Historical development of community ecology, Community concepts and attributes, Methods of sampling of plant communities, Ecological succession, Community soil-relationship, Local Vegetation, Vegetation of Pakistan, Major formation types of the world
- C. Ecosystem Ecology : Ecological concepts of ecosystem ,Boundaries of ecosystem? Compartmentalization and system concepts, Energy flow in ecosystem, Biogeochemical cycles: water carbon and nitrogen Case studies: any example

Lab Outline:

Determination of seed bank in various populations. Seed dispersal pattern of local populations. Demography and life history of local annual population. Study of community attributes. Sampling of vegetation including Quadrat, plotless, transect and Braun-Blanquet. Correlate soil properties with vegetation type. Field trip to study different communities located in different ecological regions of Pakistan. Slide show of the vegetation of Pakistan. Slide show of the major formations of the world. Soil physical and chemical properties

Recommended Books:

- 1. Schultz J.C. 2005. Plant Ecology, Springer-Verlag .
- 2. Townsend C.R. Begon. M and J.L. Harper 2002. Essentials of Ecology, Blackwell Publishing,

3. Chapin, F.S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag
4. Gurevitch, et al., 2002. The Ecology of Plants, Sinauer Associates, Inc.
5. Barbour M. G. et al., 1999, Terrestrial Plant Ecology, The Benjamin-Cumming Publishing Co.
6. Smith, R. L. 1998. Elements of Ecology by Harper & Row Publishers,
7. Moore P.D. and Chapman S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication, Oxford.
8. Hussain, S. Pakistan Manual of Plant Ecology,
9. Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education. Islamabad
10. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiological Ecology.
11. Larcher. W. 2003 Physiological Plant Ecology. Ecophysiology and Stress Physiology of Function Groups. Springer- Verlag.

Journals / Periodicals: Ecology, Journal of Ecology, Journal of Applied Ecology

Title of the Course: Bot-604 Plant Physiology-II

Credit Hours: 3(2+1)

Prerequisites: Bot. 402 & 511

Specific Objectives of course: To give it comprehensive and advance knowledge of growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism

Course Outline:

1. Plant Growth Regulators : Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal trasduction and mode of action, transport, physiological effects of Auxins , Gibberellins, Cytokinins, Absciscic

acid, Ethylene, Polyamines, Brassinosteroids, Jasmonates, and Salicylic acid.

2. Water Relations: The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants (pathways and driving forces, Aquaporins,-their structure and types). Cell water relations terminology. Hofler diagram - analysis of change in turgor, water and osmotic potential with changes in cell volume. Modulus of elasticity coefficient; Hydraulic conductivity. Osmoregulation, Methods for measurement of water , osmotic and turgor potentials- Pressure chamber, psychrometry, pressure probe, pressure volume curve.
3. Plant Mineral Nutrition: Inorganic composition of plant and soil. Absorption of mineral nutrients - roots, mycorrhizae. Effect of soil pH on nutrient availability. Ion traffic into root. The nature of membrane carriers, channels and electrogenic pumps .Passive and active (primary and secondary) transports and their energetics. Essential and beneficial elements-their functions and deficiency symptoms in plants. Fertilizers and their significance in Agriculture.
4. Phytochromes: Discovery of phytochromes and cryptochromes. Physical and chemical properties of phytochromes. Distribution of phytochromes among species, cells and tissues and their role in biological processes. Phytochromes and gene expression.
5. Control of Flowering: Autonomous versus environmental regulation. Circadian rhythms. Classification of plants according to photoperiodic reaction, photoperiodic induction, locus of photoperiodic reaction and dark periods in photoperiodism. Role of photoperiodism in flowering. Biochemical signaling involved in flowering. Vernalization and its effect on flowering. Floral meristem and floral organ development. Floral organ identity genes and the ABC model.
6. Gene Regulation and Signal Transduction : Genome size and organization. Gene regulation in prokaryotes and eukaryotes. Signal transduction in prokaryotes and eukaryotes.

Lab Outline:

1. To investigate the preferential absorption of ions by corn seedlings and potato slices.
2. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer.
3. To investigate water potential of a plant tissue by dye method and water potential apparatus.
4. Determination of K uptake by excised roots.
5. Measurement of stomatal index and conductance.
6. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.

Recommended Books:

1. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U.K.
2. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
3. Fitter, A. and Hay, R.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.
4. Heldt, H-W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
5. Ihsan Illahi, 1991. Plant Growth, UGC Press, Islamabad.
6. Ihsan Illahi, 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
7. Nobel, P.S. 1999. Physicochemical and Environmental Plant Physiology. Academic Press, UK.
8. Press, M.C., Barker, M.G., and Scholes, J.D. 2000. Physiological Plant Ecology, British Ecological Society Symposium, Volume 39, Blackwell Science, UK.
9. Salisbury F.B. and Ross C.B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
10. Taiz, L. and Zeiger, E. 2002. Plant Physiology. 3rd Edition. Sinauers Publ. Co. Inc. Calif.
11. W.B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.
12. Epstein, E. and Bloom, A.J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.

13. Kirkham, M.B. 2004. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam, Netherlands.
14. Barton, w. 2007. Recent Advances in Plant Physiology.
15. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinauers Publ. Co. Inc. Calif.

Journals / Periodicals: Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology

Title of the Course: Bot-605 Biodiversity & Conservation

Credit Hours: 3(2+1)

Prerequisites: Bot. 505, 510, 603

Specific objectives of course: To understand the importance of biodiversity, threats and conservation measures

Course Outline:

1. Introduction and importance of biodiversity :Species diversity, Ecological diversity, Genetic diversity, Social diversity
2.
 - i. Causes and depletion of biodiversity: Habitat loss, Habitat fragmentation, Over-exploitation, Climatic changes, Invasive species, .Seawater intrusion
 - ii. The value of species
 - iii. How species become endangered?
 - iv. Extinction of species, present rate. Theory of mass extinction
 - v. Inventory and monitoring of biodiversity
 - vi. Importance of red data book
 - vii. In situ and ex situ conservation of plants
 - viii. Implementation of laws (protection and conservation of various taxa.
 - ix. Sustainable use of biodiversity (plant wealth)
 - x. Protected areas of Pakistan
 - xi. Criteria for determining different categories of protected areas
 - xii. Baseline study

- xiii. Impact assessment
- xiv. Management plan for protected area
- xv. IUCN categories for threatened species
- xvi. Criteria for recognizing different categories of threatened species
- xvii. Gene bank management and operation
- xviii. Public awareness strategies.
- xix. Population explosion
- xx. Biodiversity action plan for Pakistan
- xxi. Role of herbaria and botanical gardens in conservation.

Lab Outline:

- 1 Causes of local species extinction.
- 2 Field excursion.
- 3 Data collection.
- 4 Preparation of an inventory of the flora of a given region.
- 5 To carry on base line study of any designated category.

Recommended Books:

- 1. Bush, M.B. 1997. Ecology of a Changing Planet. Prentice Hall.
- 2. Cunnighum, A.B. 2001. Applied ethnobotany: People, wild plant use and conservation. Earthspan Publications.
- 3. Cotton, C.M. (1996). Ethnobotany Principle Application. John Wiley & Sons Chichester, UK.
- 4. De Klemm, C. (1990) Wild plant conservation, IUCN, Gland.
- 5. Dyke, F.V. (2003). Conservation Biology. Mc Graw Hill, New York.
- 6. Grombridge, B. & Jenkins, M. D. (2002). World Atlas of Biodiversity: Earths Living Resources in the 21st. Century, University. California Press, Berkeley.
- 7. Heywood, V.H. 1995. Global Biodiversity Assessment. Cambridge University Press and UNEP.
- 8. Krishnamurthy, K.V. 2003. A Textbook of biodiversity Science publishers Inc. Enfield, NH, USA.
- 9. Levine, D.A. 2000. The origin, expansion and demise of plant species. Oxford University Press.
- 10. Ministry of Environment, IUCN, WWF. 1998. Biodiversity Action Plan for Pakistan.
- 11. Primack, R.B. 1998. Essentials of conservation Biology. Sinaur Association Pub. Mass. USA.
- 12. Virchow, D. (1998). Conservation of Genetic Resources. Springer-Verlag, Berlin

13. Falk, D.A. & Holsinger, K.E. 1991. *Genetics and Conservation of Rare Plants*. Center for Plant Conservation. Oxford University Press, Oxford, UK.
14. Frankel, O.H., Brown, A.H.D. & Burdon, J.J. 1995. *The Conservation of Plant Biodiversity*. Cambridge University Press, Cambridge, UK.
15. IUCN. 1994. *IUCN Red List Categories*. As Approved by the IUCN Council. IUCN.
16. French, H. 2000 *Vanishing Borders- protecting the Planet in the age of globalization*. W.W. Norton & Co
17. Swanson, T. 2005 *Global Action for Biodiversity*. Earth Scan Publication Ltd.
18. Taylor, P. 2005 *Beyond Conservation*. Earth Scan Publication Ltd.
19. Leadlay, E. and Jury, S. 2006 *Taxonomy and Plant Conservation*. CUP.

Journals / Periodicals:

Systematics and Biodiversity
Biological Conservation.

Title of the Course: Bot-606 Genetics II

Credit Hours: 3(2+1)

Prerequisites: Bot. 302 & 508

Specific Objectives of course: To introduce students to recombination of genetic material at molecular levels with emphasis on introduction to biotechnology and genomics

Course Outline:

1. Recombinant DNA :Recombinant DNA Technology – Introduction, Basic Techniques, PCR and Rt PCR, Restriction enzymes, Plasmids, Bacteriophages as tools, the formation of recombinant DNA, recombinant DNA methodology, recombinant DNA and social responsibility, Site directed Mutagenesis, DNA sequencing.
2. Application of Recombinant DNA: Applications of recombinant DNA technology using prokaryotes, recombinant DNA

technology in eukaryotes: An overview, transgenic yeast, transgenic plants, transgenic animals, screening for genetic diseases, identifying disease genes, DNA typing, gene therapy, genetically modified organisms and apprehensions.

3. Control of Gene Expression: Discovery of the *lac* system: negative control, catabolite repression of the *lac* operon: positive control, transcription: gene regulation in eukaryotes - an overview.
4. Mechanisms of Genetic Change I: Gene Mutation : The molecular basis of gene mutations, spontaneous mutations, induced mutations, reversion analysis mutagens and carcinogens, biological repair mechanisms.
5. Mechanisms of Genetic Change II: Recombination: General homologous recombination, the holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.
6. Mechanisms of Genetic Change III: Transposable Genetic Elements: Insertion sequences, transposons, rearrangements mediated by transposable elements, review of transposable elements in prokaryotes, controlling elements in maize.
7. Human Genome Project :Strategies and application, achievement and future prospects.
8. Plant Genome Projects: Arabidopsis, achievement and future prospects. Other plant genome projects
9. Bioinformatics : Application of computational tests to the analysis of genome and their gene products
10. Bioethics : Moral, Religious and ethical concerns

Lab Outline:

Problems relating to the theory

- 1 Isolation and separation of DNA and protein on Gel electrophoresis.
 - i. Bacterial chromosome
 - ii. Plasmid DNA (minipreps)

- iii. Plant DNA
- iv. Protein

2 DNA Amplification by PCR

Recommended Books:

1. Trun, N and Trempy J.,2004, Fundamental Bacterial Genetics, Blackwell Publishing House.
2. Winnacker, E.L.2003, From Gene to Clones – Introduction to Gene Technology, Panima Publishing Corporation, New Delhi.
3. Beaycgamp T.L. and Walters L., Contemporary Issues in Bioethics, Wadsworth Publishing Company.
4. Brown, T.A.,2002 Genomes, Bios Scientific Publishers Ltd.
5. The Genome of Homo Sapiens, 2003, Cold Spring Harbor Laboratory Press.
6. Ignacimuthu, S. 2005, Basic Bioinformatics, Narosa Publishing House, India,.
7. Lwein, B. 2004, Gene VIII, Pearson Education Int..
8. Miglani, 2003, Advanced Genetics, Narosa Publishing House, India,.
9. Hartt, D. L, and Jones, E.W. 2005. Genetics, Analysis of Gene and Genomes. Jones and Bartlett Publishers, Sudbury, USA
10. Gelvin, S.B. 2000. Plant Molecular Biology Manual. Kluwer Academic Publishers.
11. Primrose, S.B., Twyman, R. M. and Old R.W. 2004. Principles of Gene Manipulation, an Introduction to Genetic Engineering (6th edition), Blackwell Scientific Publications.
12. Snyder, L and Champness W, 2003, Molecular Genetics of Bacteria, ASM Press,.
13. Wilson, J. and Hunt, T. 2004. Molecular Biology of the cell – the problems book, Garland publishing Inc.

Journals / Periodicals: J. Genetics, Theoretical and Applied Genetics, Cytologia, Chromosoma, Genome

8th Semester

Title of the Course: Botany-607 Environmental Biology

Credit Hours: 3(2+1)

Prerequisites: Bot. 510 & 603

Specific Objectives of course: To provide updated knowledge of environmental problems and sustainable environmental management.

Course Outline:

1. Environment: Introduction, scope, pressure
2. Pollution: definition, classification and impact on habitats
 - i. Air pollution: Sources and effect of various pollutants (inorganic, organic) on plants, prevention, control, remediation. Photochemical smog. Smog. Acid rain: 1. Theory of acid rain, 2. Adverse effects of acid rains. Chlorofluorocarbons and its effects.
 - ii. Water pollution: Major sources of water pollution and its impact on vegetation. prevention, control remediation, eutrophication, thermal pollution.
 - iii. Sediments pollution: fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control remediation. Heavy metal pollution. Tanneries. Hospital waste. Treatments of sewage, sludge, and polluted waters.
 - iv. Noise pollution.
 - v. Radiation pollution (including nuclear): Measurement, classification and effects, Principle of radiation protection, waste disposal
3. Forest: importance, deforestation, desertification and conservation
4. Ozone layer:
 - i. Formation
 - ii. Mechanism of depletion
 - iii. Effects of ozone depletion
5. Greenhouse effect: causes, impacts.
6. Human population explosion: impact on environment.
7. Impact assessment: Industrial urban, civil developments.

8. National conservation strategy: Brief review of major problems of Pakistan and their solutions.
9. Sustainable Environmental management.
10. Wetlands and sanctuaries protection: The pressures, problems and solutions.
11. Range management: Types of rangelands, potential threats, sustainable management.

Lab Outline:

1. Examination of industrial waste water and Municipal sewage and sludge for
 - i. Total dissolved solids.
 - ii. pH and EC.
 - iii. BOD/COD.
 - iv. Chlorides, carbonate, and Nitrates.
2. Examination of water samples forms different sites for the presence and diversity of organisms.
3. Effect of air pollutants on plants.
4. Visits to environmentally compromised sites and evolution of remediation methods.

Recommended Books:

1. Newman, E.I. 2001. Applied Ecology. Blackwell Science. UK
2. Mooney, H.A. and Saugier, B. 2000. Terrestrial Global Productivity. Academic Press, UK.
3. Eugene, E.D. and Smith, B.F. 2000. Environmental Science: A study of interrelationships. McGraw Hill. USA.
4. French, H. 2000. Vanishing Borders: Protecting the Planet in the Age of Globalization. W.W. Norton and Company, NY.
5. Hall, C.A.S. and Perez, C.L. 2000. Quantifying Sustainable Development. Academic Press, UK.
6. Bazzaz, F.A. 2004. Plants in changing environments: Linking physiological, population, and community ecology. Cambridge Univ. Press.
7. Bush, M.B. 1997. Ecology of a changing planet. Prentice Hall, UK.
8. Marsh, M.W. and Grossa Jr., J.M. 1996 Environmental geography: Science, land use, and earth systems. John Wiley and Sons.

9. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiological Ecology.

Journals/Periodicals: Environmental Biology, Environment, Bioremediation

Title of the Course: Botany Special Paper-II

Credit Hours: 4(3+1)

Prerequisites: Botany

Specific Objectives of course:

Course Outline: To be adopted by the university as per expertise

Lab Outline:

Recommended Books:

Journals / Periodicals:

Title of the Course: Bot-608 Special Paper-II

Credit Hours: 4(3+1)

Prerequisites:

Specific Objectives of course:

Course Outline: To be adopted by the university as per expertise

Lab Outline:

Recommended Books:

Journals / Periodicals:

RESEARCH 4(0+4)

Total credit hours: 133

GENERAL RECOMMENDATIONS (BOTANY)

After a comprehensive discussion by all the members of the committee constituted by HEC to adapt the curriculum (devised by HEC) following points were noted:

- This document contained information which was general for all the disciplines.
- It was unanimously adapted with minor modifications made.

While restructuring the scheme of study semester wise for BS 4 years programme in Botany, there were general feelings that we should accommodate for the phasing out of existing 2 year degree programme and phasing in the modern 4 years degree programme. Accordingly, courses were selected compatible to meet the current and future needs. Nevertheless emphasis was on the creation of a document that should be attractive and useful for the introduction of BS 4 years degree programme in Botany for public / private sector universities. Therefore following recommendations were made:

1. That HEC should write to Federal and Provincial Public Service Commissions for formal recognition of the BS 4 years degree programme and it must be considered equivalent to the existing M.Sc. (16 years schooling programme).
2. That HEC should provide sufficient funds to the colleges and the universities to initiate such new degree programmes. Universities and colleges offering these courses should organize training and workshops before initiating degree programme.
3. That HEC should ensure that the institutions have at least eight teachers (at least 2 teachers having M.Phil Degree).
4. That the Internship and Research projects should be encouraged but it should not be mandatory at this juncture as we do not have a culture of Internships and Research activities in the disciplines of Botany in our country.

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

English – I (Functional English)

Objectives: Enhance language skills and develop critical thinking.

Course Contents

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

Comprehension

Answers to questions on a given text

Discussion

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

Listening

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

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Recommended books:

1. **Functional English**
 - a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
 2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506
- b) Writing
1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
- c) Reading/Comprehension
1. Reading. Upper Intermediate. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.
- d) Speaking

ENGLISH – II (COMMUNICATION SKILLS)

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

Course Contents

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

CV and job application

Translation skills

Urdu to English

Study skills

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

Academic skills

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

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended books:

Communication Skills

- a) Grammar
 - 1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
- b) Writing
 - 1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 45-53 (note taking).
 - 2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
- c) Reading
 - 1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
 - 2. Reading and Study Skills by John Langan
 - 3. Study Skills by Richard Yorky.

ENGLISH – III

(TECHNICAL WRITING AND PRESENTATION SKILLS)

Objectives: Enhance language skills and develop critical thinking

Course Contents

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

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

Technical Report writing
Progress report writing

Note: *Extensive reading is required for vocabulary building*

RECOMMENDED BOOKS

Technical Writing and Presentation Skills

- a) Essay Writing and Academic Writing
 1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
 2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
 3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
- b) Presentation Skills
- c) Reading
The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Pakistan Studies (Compulsory)

Introduction/Objectives

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

Course Outline

1. Historical Perspective

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

2. Government and Politics in Pakistan

Political and constitutional phases:

- a. 1947-58
- b. 1958-71
- c. 1971-77
- d. 1977-88
- e. 1988-99
- f. 1999 onward

3. Contemporary Pakistan

- a. Economic institutions and issues
- b. Society and social structure
- c. Ethnicity
- d. Foreign policy of Pakistan and challenges

e. Futuristic outlook of Pakistan

Books Recommended

1. Burki, Shahid Javed. *State & Society in Pakistan*, The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy*. Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. *Pakistan's Foreign policy: An Historical analysis*. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development*. Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Banglades.*, Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development*. Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh*. Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan*. Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, *Pakistan Under Martial Law*, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective*. Islamabad: National Commission on Historical and Cultural Research, 1993.

ISLAMIC STUDIES (Compulsory)

Objectives:

This course is aimed at:

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

DETAIL OF COURSES

Introduction to Quranic Studies

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

Study of Selected Text of Holly Quran

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

Study of Selected Text of Holly Quran

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

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

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

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

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

Introduction To Sunnah

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

Selected Study from Text of Hadith

Introduction To Islamic Law & Jurisprudence

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

Islamic Culture & Civilization

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

Islam & Science

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

Islamic Economic System

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

Political System of Islam

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

Islamic History

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

Social System of Islam

- 1) Basic Concepts Of Social System Of Islam
- 2) Elements Of Family
- 3) Ethical Values Of Islam

Reference Books:

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

ANNEXURE “D”

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

COMPULSORY MATHEMATICS COURSES FOR BS (4 YEAR) (FOR STUDENTS NOT MAJORING IN MATHEMATICS)

1. MATHEMATICS I (ALGEBRA)

Prerequisite(s): Mathematics at secondary level

Credit Hours: 3 + 0

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

Course Outline:

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

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

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression.

Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices.

Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Recommended Books:

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

Boston (suggested text)

Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston

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

2. MATHEMATICS II (CALCULUS)

Prerequisite(s): Mathematics I (Algebra)

Credit Hours: 3 + 0

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

Course Outline:

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

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.

Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Recommended Books:

Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York

Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text)

Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston

Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

3. MATHEMATICS III (GEOMETRY)

Prerequisite(s): Mathematics II (Calculus)

Credit Hours: 3 + 0

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

Course Outline:

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

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

Recommended Books:

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

4. COURSE FOR NON-MATHEMATICS MAJORS IN SOCIAL SCIENCES

<i>Title of subject</i> :	MATHEMATICS
<i>Discipline</i> :	BS (Social Sciences).
<i>Pre-requisites</i> :	SSC (Metric) level Mathematics
<i>Credit Hours</i> :	03 + 00
<i>Minimum Contact Hours</i> :	40
<i>Assessment</i> :	written examination;
<i>Effective</i> :	2008 and onward

Aims : To give the basic knowledge of Mathematics and prepare the students not majoring in mathematics.

Objectives : After completion of this course the student should be able to:

- Understand the use of the essential tools of basic mathematics;
- Apply the concepts and the techniques in their respective disciplines;
- Model the effects non-isothermal problems through different domains;

Contents :

1. *Algebra* : *Preliminaries*: Real and complex numbers, Introduction to sets, set operations, functions, types of functions. *Matrices*: Introduction to matrices, types of matrices, inverse of matrices, determinants, system of linear equations, Cramer's rule. *Quadratic equations*: Solution of quadratic equations, nature of roots of quadratic equations, equations reducible to

quadratic equations. *Sequence and Series*: Arithmetic, geometric and harmonic progressions. *Permutation and combinations*: Introduction to permutation and combinations, *Binomial Theorem*: Introduction to binomial theorem. *Trigonometry*: Fundamentals of trigonometry, trigonometric identities. *Graphs*: Graph of straight line, circle and trigonometric functions.

2. **Statistics** : *Introduction*: Meaning and definition of statistics, relationship of statistics with social science, characteristics of statistics, limitations of statistics and main division of statistics. *Frequency distribution*: Organisation of data, array, ungrouped and grouped data, types of frequency series, individual, discrete and continuous series, tally sheet method, graphic presentation of the frequency distribution, bar frequency diagram histogram, frequency polygon, cumulative frequency curve. *Measures of central tendency*: Mean median and modes, quartiles, deciles and percentiles. *Measures of dispersion*: Range, inter quartile deviation mean deviation, standard deviation, variance, moments, skewness and kurtosis.

Recommended Books:

1. Swokowski. E. W., '*Fundamentals of Algebra and Trigonometry*', Latest Edition.
2. Kaufmann. J. E., '*College Algebra and Trigonometry*', PWS-Kent Company, Boston, Latest Edition.
3. Walpole, R. E., '*Introduction of Statistics*', Prentice Hall, Latest Edition.
4. Wilcox, R. R., '*Statistics for The Social Sciences*',
5. Mathematics For Chemistry

Credit Hours: 3

Prerequisites: Mathematics at Secondary level

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

Course Outline:

Preliminaries: Real Numbers and the Real Line, *Functions and their graphs:* Polynomial Functions, Rational Functions, Trigonometric Functions, and Transcendental Functions. Slope of a Line, Equation of a Line, Solution of equations involving absolute values, Inequalities. *Limits and Continuity:* Limit of a Function, Left Hand and Right Hand Limits, Continuity, Continuous Functions. *Derivatives and its Applications:* Differentiation of Polynomial, Rational and Transcendental Functions, Extreme Values of Functions. *Integration and Indefinite Integrals:* Integration by Substitution, Integration by Parts, Change of Variables in Indefinite Integrals. Least-Squares Line.

Recommended Books:

1. Thomas, Calculus, 11th Edition. Addison Wesley publishing company, 2005.
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th edition, Jhon Willey & Sons, Inc. 2005.
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A.Jr, Elliott Mendelson, Calculus, Schaum's Outline Series, 4th edition, 1999.
5. E. W. Swokowski, Calculus and Analytic Geometry PWS Publishers, Boston, 1983.
6. John H. Mathews, Numerical Methods for Mathematics Science and Engineering, Prentice-Hall, Second Edition 1992.

6. MATHEMATICS FOR PHYSICS

Contents

1. Preliminary calculus.
 - Differentiation
Differentiation from first principles; products; the chain rule; quotients; implicit differentiation; logarithmic differentiation; Leibnitz' theorem; special points of a function; theorems of differentiation.
 - Integration
Integration from first principles; the inverse of differentiation; integration by inspection; sinusoidal function; logarithmic integration; integration using partial fractions; substitution method; integration by parts; reduction formulae; infinite and improper integrals; plane polar coordinates; integral inequalities; applications of integration.

2. **Complex numbers and hyperbolic functions**

- The need for complex numbers
- Manipulation of complex numbers
Additions and subtraction; modulus and argument; multiplication; complex conjugate; division
- Polar representation of complex numbers
Multiplication and division in polar form
- de Moivre's theorem
Trigonometrical identities; finding the n th roots of unity; solving polynomial equations
- Complex logarithms and complex powers
- Applications to differentiation and integration
- Hyperbolic functions
Definitions; hyperbolic-trigonometric analogies; identities of hyperbolic functions; solving hyperbolic equations; inverses of hyperbolic functions; calculus of hyperbolic functions.

3. **Series and limits**

- Series
- Summation of series
Arithmetic series; geometric series; arithmetico-geometric series; the difference method; series involving natural numbers; transformation of series
- Convergence of infinite series
Absolute and conditional convergence; convergence of a series containing only real positive terms; alternating series test
- Operations with series
- Power series
Convergence of power series; operations with power series
- Taylor series
Taylor's theorem; approximation errors in Taylor series; standard Maclaurin series
- Evaluation of limits

4. **Partial differentiation**

- Definition of the partial derivative
- The total differential and total derivative
- Exact and inexact differentials

- Useful theorems of partial differentiation
- The chain rule
- Change of variables
- Taylor's theorem for many-variable functions
- Stationary values of many-variable functions
- Stationary values under constraints

5. **Multiple integrals**

- Double integrals
- Triple integrals
- Applications of multiple integrals
Areas and volumes; masses, centers of mass and centroids; Pappus' theorems; moments of inertia; mean values of functions
- Change of variables in multiple integrals
Change of variables in double integrals;

6. **Vector algebra**

- Scalars and vectors
- Addition and subtraction of vectors
- Multiplication by a scalar
- Basis vectors and components
- Magnitude of a vectors
- Multiplication of vectors
Scalar product; vector product; scalar triple product; vector triple product
- Equations of lines and planes
Equation of a line; equation of a plane
- Using vectors to find distances
Point to line; point to plane; line to line; line to plane
- Reciprocal vectors

7. **Matrices and vector spaces**

- Vectors spaces
Basic vectors; the inner product; some useful inequalities
- Matrices
- The complex and Hermitian conjugates of a matrix
- The determinant of a matrix
Properties of determinants
- The inverse of a matrix
- The rank of a matrix
- Simultaneous linear equations
N simultaneous linear equations in N unknowns
- Special square matrices

Diagonal; symmetric and antisymmetric; orthogonal; Hermitian; unitary normal

- Eigen vectors and eigen values of a normal matrix; of Hermitian and anti-Hermitian matrices; of a unitary matrix; of a general square matrix
- Determination of eigen values and eigen vectors degenerate eigen values

8. **Vector calculus**

- Differentiation of vectors
Composite vector expressions; differential of a vector
- Integration of vectors
- Space curves
- Vector functions of several arguments
- Surfaces
- Scalar and vector fields
- Vector operators
Gradient of a scalar field; divergence of a vector field; curl of a vector field
- Vector operator formulae
Vector operators acting on sums and products; combinations of grad, div and curl
- Cylindrical and spherical polar coordinates
Cylindrical polar coordinates; spherical polar coordinates

INTRODUCTION TO STATISTICS

Credit hrs: 3(3-0)

Unit 1. What is Statistics?

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

Unit 2. Presentation of Data

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

Unit 3. Measures of Central Tendency

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

Unit 4. Measures of Dispersion

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

Unit 5. Probability and Probability Distributions.

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

Unit 6. Sampling and Sampling Distributions

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

Unit 7. Hypothesis Testing

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

Unit 8. Testing of Hypothesis- Single Population

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

Unit 9. Testing of Hypotheses-Two or more Populations

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

Unit 10. Testing of Hypothesis-Independence of Attributes

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

Unit 11. Regression and Correlation

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

Recommended Books

- 1 Walpole, R. E. 1982. "Introduction to Statistics", 3rd Ed., Macmillan Publishing Co., Inc. New York.
- 2 Muhammad, F. 2005. "Statistical Methods and Data Analysis", Kitab Markaz, Bhawana Bazar Faisalabad.

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

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