FACULTY OF LIFE SCIENCES

SYLLABUS

FOR

Pre-Ph.D Course in Botany
(Credit Based Evaluation & Grading System)

Examinations: 2019-20

GURU NANAK DEV UNIVERSITY
AMRITSAR

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    Please visit the University website time to time.
# Pre Ph.D. Course in Botany
(Credit Based Evaluation & Grading System)

Programme Code: BSZ
Pre Ph.D. Course in Botany
Scheme of Courses for Pre Ph.D. Course in Botany Semester I

<table>
<thead>
<tr>
<th>Course No.</th>
<th>C/E/I</th>
<th>Course Title</th>
<th>Credits</th>
<th>Total Credits</th>
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<td>Core Courses</td>
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<td>LSL901</td>
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<td>Research Methodology</td>
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<td>Elective Courses (3 Credits)</td>
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<td>Interdisciplinary/ Optional Courses (3 Credits)</td>
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| Total Credits | 15 1 1 17 |

**List of Elective Courses**

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<th>C/E/I</th>
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<td>Phytochemical Techniques</td>
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<td>BSL962</td>
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<td>Phytonanotechnology</td>
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<td>BSL964</td>
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<td>Perspectives in Biodiversity</td>
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<td>Nutraceuticals and Herbal Remedies</td>
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<td>Disaster Management</td>
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<td>Phytoremediation</td>
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<td>ESL963</td>
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<td>Cancer: Genes and Environment</td>
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<td>Good Laboratory Practices</td>
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<td>Water Supply Engineering &amp; Management</td>
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<td>E</td>
<td>Soil and Environment</td>
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<td>ESL967</td>
<td>E</td>
<td>Design and Analysis of Experiments</td>
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Pre Ph.D. Course in Botany  
(Credit Based Evaluation & Grading System)

LSL-901 - Research Methodology

Credits 3-1-0
Max. Marks : 100
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

Note: The course will be numerical oriented to train the students for the analysis of research data. Use of calculators will be allowed in the examination.

SECTION-A
1. **Descriptive statistics**: Statistical expressions, central tendency, dispersion of data (arithmetic and geometric), moments, skewness, kurtosis, sample size estimation.
2. **Probability**: Concept of probability, conditional probability, distributions: Normal, Poisson, binomial, ‘t’, χ², F-distributions.

SECTION-B
3. **Testing of hypothesis**: Central limit theorem, null hypothesis and alternative hypotheses, Z-test, Student’s t-test, χ²-square, F-test, sample size, confidence intervals. odds ratio, index numbers, Probit analysis.
4. **Correlation and regression analysis**: Linear correlation and regression, exponential regression, logarithmic regression, reciprocal regression, Michael-Menten’s regression, logistic regression, Gompertz regression, monomolecular regression.

SECTION-C
5. **Multiple correlation and regression**: MLR with 2 and 3 independent variables, quadratic and cubic polynomial regressions, Beta regression, sine curve, multiple correlation, partial correlation, path analysis, time series analysis.
6. **Experimental designs**: Experimental designs, central composite designs with 2 and 3 factors.

SECTION-D
7. **Analysis of Variance**: Assessing normality, one way and 2-way ANOVA, Tukey's multiple comparison test, HSD.
9. **Non-parametric tests**: Wilcoxon’s, Mann-Whitney’s tests, Spearman’s rank correlation, Kendall’s Tau.
10. **Basic Greek and Latin words**: The students will learn Greek alphabet and more than 100 basic roots and words used in science.

Note: The students will be asked to submit an assignment of computer softwares designed by them on the basis of the Research methodology syllabus.
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BSL961-Phytochemical Techniques

Credits 3-0-0
Max. Marks : 100
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

1. Production Processes for Herbals and Botanicals:
   i. Introduction
   ii. Cultivation
   iii. Collection from the Wild
   iv. Cleaning
   v. Drying
   vi. Packaging of Dried Plants

2. Selection of plant and plant parts for phytochemical analysis
3. Methods of extraction:
   i. Organic Solvent Extraction: Maceration, Percolation, Cold Percolation, Countercurrent Extraction
   ii. Extraction with Supercritical Gases
   iii. Steam Distillation
   iv. Other Minor Extraction Methods
   v. Extraction of Essential Oil
   vi. Soxhlet Extractor
   vii. Accelerated Solvent Extractor

SECTION-B

4. Qualitative phytochemical screening:
   i. Detection of Alkaloids
   ii. Detection of Carbohydrates and Glycosides
   iii. Detection of Saponins
   iv. Detection of Proteins and Amino Acids
   v. Detection of Phytosterols
   vi. Detection of Fixed Oils and Fats
   vii. Detection of Phenolic Compounds and Tannins
   viii. Detection of Gum and Mucilages
   ix. Detection of Volat

5. Qualitative/Quantitative estimation of phytochemicals:
   i. Chromatography: Introduction, Theoretical Principles
   ii. Paper Chromatography: Introduction, Theoretical Principles, Instrument, Sample Handling, Detection and of Components
   iii. Thin layer Chromatography: Introduction, Theoretical Principles, Instrument, Sample Handling, TLC Plate Visualization by Spraying and Dipping
   iv. Column Chromatography: Introduction, Theoretical Principles, Instrument, Sample Handling
   v. Gas Chromatography: Introduction, Theoretical Principles, Instrument, Sample Handling, Chromatogram
   vi. Liquid Chromatography: Introduction, Preparative Chromatography
   vii. High Performance Liquid Chromatography: Introduction, Principles High Performance Liquid Chromatography, HPLC Instrument, Sample Handling, Identification, Qualitative and Quantitative Analysis
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SECTION-C

6. Methods of identification:
   i. Introduction
   ii. Physical Characteristics: Introduction, Colour, Odour, Acid or Base character, Solubility, Melting Point, Boiling Point,
   iii. Spectroscopy: Introduction,
   viii. Nuclear Magnetic Resonance Spectroscopy: Introduction, Theoretical Principles, Carbon-13 NMR (13C NMR), Hydrogen-1 NMR (1H NMR), Instrument, Sample Handling, Interpretation of NMR Spectra, Different Techniques of NMR.

SECTION-D

7. Categories of Phytochemicals:
   i. Introduction
   ii. Terpenoids: Introduction, General Properties of Terpenoids, Classification of Terpenoids, Determination of Structure of Terpenoids, Monoterpenoids, Sesquiterpenoids, Diterpenoids, Triterpenoids, Pentaterpenoids, Essential Oils
   iii. Steroids: Introduction, Stereochemistry of Steroids, Sterols, Steroidal Alkaloids
   iv. Phenolic Compounds: Introduction, Phenylpropanoids, Flavonoids
   v. Alkaloids: Introduction, Distribution, Properties, Test for Alkaloids, Extraction of Alkaloids, Structure and Classification
   vi. Glycosides
   viii. Lipids and Related Compounds: Introduction, Classification of Lipids, Fats and Oils, Waxes, Phospholipids
   ix. Plant Pigments: Introduction, Chlorophylls, Carotenoids, Phycobilins, Anthocyanins
   x. Vitamins: Introduction, Classification of Vitamins, Sources of Vitamins, Structures of Vitamins.
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BSL962 – Phytonanotechnology

Time: 3 Hrs.

Max. Marks : 100
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

SECTION-B
2. Toxicology of nanoparticles. Environmental Nanoparticles Interactions with Plants: Morphological, Physiological, and Genotoxic Aspects.

SECTION-C

SECTION-D

References:
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BSL963 - Cell Signalling  
Credits 3-0-0  
Max. Marks : 100  
Mid Semester Marks : 20  
End Semester Marks : 80

Mid Semester Examination: 20% weightage  
End Semester Examination: 80% weightage

Time: 3 Hrs.

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

1. Aspects of cellular signalling: Introduction, the main principles of cell signalling Different ways in which cells signal to each other: Electrical and synaptic, Endocrine, Paracrine, Autocrine, Direct cell- Cell signalling, Receptor-ligand signalling, Gap junctions and plasmodesmata, Coordination of signalling, Domains and modules, Oncogenes.

2. The techniques in the study of cell signalling components: Labeling techniques, The use of probes, Pharmacological tools; Structure and protein interactions. Molecular genetic techniques; Microarrays and proteomics; Computer networks.

3. Extracellular signals: hormones, cytokines, and growth factors: Small water-soluble molecules. Peptide hormones lipophilic molecules which are detected by cell-surface receptors lipophilic molecules which are detected by intracellular receptors.

Plant hormones: Auxin, Cytokinins, Gibberellins. Abscisic acid, Ethylene, Other plant hormones, Cytokines, Interleukins, Interferons, Tumour necrosis factors, Other cytokines, chemokines, and receptors.


SECTION-B

4. Detection of extracellular signals the role of receptors: Types of receptor: G protein-linked receptors, Ion channel-linked receptors, Receptors containing intrinsic enzymatic activity, Receptors linked to separate tyrosine kinases, Intracellular receptors of extracellular signals. Ligand binding to their receptors, Receptor sensitivity and receptor density.


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SECTION-C
6. **Cyclic nucleotides, cyclases, and G proteins**: cAMP, Adenylyl cyclase, Adenylyl cyclase control and the role of G proteins, The heterotrimeric G protein family, The roles of the β/γ complex, Other roles of the heterotrimeric G proteins.
Guanylyl cyclase: Soluble guanylyl cyclase, Membrane-bound guanylyl cyclase, Phosphodiesterases


SECTION-D

9. **Reactive oxygen species, reactive nitrogen species, and redox signalling**: Nitric oxide: Other enzymatic sources of NO. Reactive oxygen species: superoxide and hydrogen peroxide, Evidence for superoxide and hydrogen peroxide acting as a signal. The NADPH oxidase complex, Chronic granulomatous disease, non-phagocytes, and plants, Other sources of superoxide. Redox signalling and molecular mechanisms of hydrogen peroxide signalling, Measuring ROS and RNS. Carbon monoxide

10. **Insulin and the signal transduction cascades it invokes**: The insulin signalling system


References:
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BSL964 - Perspectives in Biodiversity

Credits 3-0-0
Max. Marks : 100
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Time: 3 Hrs.

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
1. Concept of biosphere and biodiversity, relation between biodiversity, biogeography, physiography and stratigraphy. A review of the theories of continental drift and plate tectonics, glaciations of the geological past and effects on the living world. The phytogeographic provinces and districts of the world.
2. Biodiversity through time, major events in the evolution of living beings through the geological past, rates of diversification and phylogenetic splitting, geological and ecological causes of extinction, lifespan of species, background rates and mass extinctions.

SECTION-B
3. Within-habitat (alpha) level, species counts, species richness and species heterogeneity, probability theory and entropy theory based indices of species heterogeneity, equitability and evenness of distribution, SHE analysis.
4. Between-habitat directionless beta diversity (heterogeneity) of habitats, directional (turnover) diversity through gradients of time (diachronic) and space (synchronic). Changes in species and composition along altitudinal and depth gradients of terrestrial and aquatic habitat, comparative study, indices after Jaccard, Sorensen, Whittaker, Cody, Wilson and Schmida, Colwell and Coddington.

SECTION-C
5. Landscape (gamma) level, exhaustive species count, the use of models of species area relationships in estimating landscape level diversity, scale dependence, homogenization and SAR curves. The evolutionary (historical) causes of biodiversity in specific areas.
6. Relative density, frequency, abundance and dominance of species in community. Ranked abundance and importance value. Concepts and models of dominance diversity relationship, methods of fitting data to various models.
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**SECTION-D**

8. Ecological uses of biodiversity, relation with stability, productivity and invasibility of ecosystem. Invasive species and the factors of their success, elements of landscape ecology, indices of diversity, core and edge species, rare and generalist species, effect of patch shape on diversity, perimeter area ratio effects.

9. Biodiversity as a resource for human welfare, conservation status of habitat and species, conservation efforts, important conventions and treaties.

10. Current extinction rates, causes and consequences, differential extinction rates in taxonomic groups, mass extinctions, evolutionary causes and significance of endemism.

**References:**

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BSL966 – Nutraceuticals and Herbal Remedies  
Credits 3-0-0

Time: 3 Hrs.

Max. Marks : 100  
Mid Semester Marks : 20  
End Semester Marks : 80

Mid Semester Examination: 20% weightage  
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
1. Introduction to herbs and ayurveda: Concept of tridosha, role of pancha karma in ayurveda, origin of Charka samhita, comparison of ayurveda with other systems of healing likes unani, siddha, homeopathy and yoga.

SECTION-B
2. Nutraceuticals: General introduction, classification of nutraceuticals, inorganic mineral supplements, vitamin supplements, dietary fibres, antioxidants, health drinks, natural sweeteners, cereals and grains, polyunsaturated fatty acids. Herbal product formulations for skin and healthcare, brain tonics and anti-aging products; their manufacturers and suppliers; export market hub of herbs.

SECTION-C

SECTION-D
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ESL961 - Disaster Management

Credits 3-0-0
Max. Marks : 100
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Time: 3 Hrs.

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
1. Introduction to disasters, common terminologies. Management acts, policies & institutions in India.
2. Earthquakes
   Damage Prevention and Rehabilitation by Retrofitting
   Dos and Don'ts While Constructing Buildings
   Case study-Bhuj Earthquake 2001

SECTION-B
3. Floods
   Standard Operating Procedure for Administration
   Standard Operating Procedure for Individuals
   Case study-Assam Floods 2004
4. Cyclones
   Case study-Orissa Super Cyclone 1999
5. Droughts

SECTION-C
6. Landslides
7. Fire disasters-Forest Fires
   Case study-Peerchu Lake – A Disaster in Being Kumbakonam School Fire Tragedy
8. Avalanches
9. Tsunami
   Case study-Tsunami 2004
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SECTION-D  

9. Nuclear Disasters  
   Dos and Don'ts While Commercial Nuclear Disaster  

10. Chemical and industrial Disasters  
   Chemical and Industrial Disaster Mitigation  
   Case study-Bhopal Gas Tragedy 1984  

Note: Related Case Studies can be included as per the topic.  

References:  


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ESL962 - Phytoremediation  
Credits 3-0-0  
Max. Marks : 100  
Mid Semester Marks : 20  
End Semester Marks : 80  

Time: 3 Hrs.  
Mid Semester Examination: 20% weightage  
End Semester Examination: 80% weightage  

Instructions for the Paper Setters:  
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section. 

SECTION A  

SECTION B  
2. Soil Plant Microbe Interaction: Mycorrhizal Fungi as helping agents in "phytoremediation of degraded and contaminated soils; The Rhizosphere Ecology; Rhizoremediation potential for selective plant microbe pairs. Role for chelates and enzymes in phytoremediation: Heavy metal removal Glucosyltransferase and Glutathione S-transferase in Phytoremediation. 

SECTION C  

SECTION D  
4. Phytoremediation of Pollutants: Organic and Inorganic pollutants; Phytoremediation of Polychlorinated Biphenyls, Volatile Organic Compounds and Heavy metals from soil; Exploitation of fast growing trees in metal remediation.  

Regulatory Evaluation and Acceptance Issues for Phytotechnologies: Assessing risks and Containing or mitigating gene flow of phytoremediating plants.
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References:
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ESL963 - Cancer: Genes and Environment

Credits 3-0-0
Max. Marks : 100
Mid Semester Marks : 20
End Semester Marks : 80

Time: 3 Hrs.

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

1. Common Types of Cancer: Terminology, bladder cancer, brain cancer, breast cancer, leukemia, lung cancer, prostate cancer, skin cancer. Cancer cells: Cancer cells are immortal, broken chromosomes a failure to communicate, they go where they please, one mutation is not enough.

SECTION-B


SECTION-C


SECTION-D


References:
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ESL964 - Good Laboratory Practices

Credits 3-0-0  
Max. Marks : 100  
Mid Semester Marks : 20  
End Semester Marks : 80

Mid Semester Examination: 20% weightage  
End Semester Examination: 80% weightage

Time: 3 Hrs.

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

1. Introduction to chemical analysis: Nature of analytical chemistry, general directions of chemical analysis: Cleanliness in the laboratory, Recording and planning data. Data quality: Bias, Precision, Uncertainty, Method detection limit, Checking correctness of analysis, Expression of results, Significant figures, Collection and preservation of sample,

SECTION-B


SECTION-C

4. Chemical reagents and standards: Grade and purity of chemicals, Proper storage of chemicals and standards, Laboratory pure water, Preparation of reagent grade water, Reagent water quality.

5. Reagents and solutions. Stock standardization solutions, Preparation and standardization of common standard solutions,

SECTION-D

6. Filtration: Gravity, Vacuum, Centrifugation, Distillation: Simple, Fractional, Vacuum, Refluxing, Ion exchange, Drying and ashing sample, Liquid liquid extraction by separating funnel, Soxhlet extraction.

7. Software’s for stock room management, Role of computers in Laboratory occupational health and safety, Waste minimization and disposal.

References:

1. Csuros, M., Environmental Sampling and Analysis, Lewis Publications.
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ESL-965 Water supply Engineering and Management  
Credits 3-0-0  
Max. Marks : 100  
Mid Semester Marks : 20  
End Semester Marks : 80

Time: 3 Hrs.  
Mid Semester Examination: 20% weightage  
End Semester Examination: 80% weightage

Instructions for the Paper Setters:  
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
1. **Concepts of water supply Engineering:** Roman and Indus valley civilizations, five year plans of India, Appointment of Environmental Hygiene Committee, Importance of water, Necessity of water supply scheme, Importance and reliability of water works, objectives of water supply scheme/system.

2. **Quantity of Water:** Quantity of water required, design period, factors affecting design period, types of demand, per capita consumption demand, domestic demand, commercial and industrial demand, fire demand, public use demand, factors affecting demand: Variation/fluctuations, forecasting population: Arithmetical increase method, geometrical increase method, incremental increase method, decreasing rate of growth method, graphical method.

SECTION-B
3. **Sources of water:** Types: surface sources; impound reservoirs, rainfall, measurements of rainfall: Symon’s rain gauge, Runoffs and their measurement: Guaging method; empirical formulae method: Dicken’s formulae, Ryve’s formulae, Inglish formulae, Burge’s formulae, Rational methods, ground water sources: infiltration galleries, porous pipe galleries, Wells and types: infiltration wells, open or dug wells, driven wells, tube wells etc.

4. **Collection and conveyance of water:** Selection of site, Types and designs of water intake, means of conveyance of water, Types of pipes and joints, testing of pipe lines, back filling.

5. **Quality of water:** wholesome water, impurities of water; physical, chemical, bacteriological examination of water, Standards of quality of water, water borne diseases, prevention of water borne diseases.

SECTION-C
6. **Water Treatment:** Water treatment units, impurities removed by various treatment processes, location of treatment plants, important consideration of public water supply, Public health laboratory, types of disinfection: boiling, long storage, ozone, potassium permagnate, excess lime, UV rays, iodine and bromine, chlorination, Softening of water and its methods: lime soda process, zeolite or Base Exchange method.

7. **Distribution of water:** Appurtenances used for controlling the flow of water, fire hydrants scour, safety valves, reflux and check valves, layout of distribution systems: dead end system, grid iron system, ring system, radial system; methods of distributions; pumping method, gravity flow method, typical layout of water supply, service reservoirs.
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SECTION-D

8. **Building Water Supply**: Layout of water supply arrangement for a building, water supply fixtures and fittings, service connections.

9. **Maintenance of Water Supply Systems**: leakage and wastage of water, factors affecting loses and wastes locations of underground pipes, replacement of damage pipes, records of whole water supply system.

References


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ESL966 - Soil and Environment  
Credits 3-0-0

Time: 3 Hrs.

Max. Marks: 100
Mid Semester Marks: 20
End Semester Marks: 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
1. **Introduction:** Soil as component of ecosystems, Soil and man, soil pollution Soil components: Texture and structure, bulk density, pore space, soil water, soil air, mineral, organic and chemical components of soil, Interactions between soil components.

2. **Development of soils:** Rock and their weathering, addition and decomposition of organic matter, processes of soil formation, soil horizons, soil classification and characteristics.

3. **Sorptive properties of soil:** Electrically charged surfaces, Exchangeable cations and cation exchange capacity, Diffuse layer, Selectivity of cation adsorption, Anion retention, sorption of gases.

SECTION-B
4. **Organisms and soil processes:** Organic materials sources and decomposition, Soil fauna, soil microorganisms, biological nitrogen fixation, Ammonification, nitrification, denitrification, Oxidation and reduction.

5. **Soil as a medium for plant growth:** Plant development and growth, Restrictions to root growth, Requirements of water and nutrients, rhizosphere and mycorrhizas, cultivations, fertilizers, organic manures.

SECTION-C
6. **Soil acidification:** pH and buffering, Percentage base saturation, Processes of soil acidification, Effects of acidity on plants, Acid rain, Acidification of ecosystems Heavy metals and radionuclides in soil: Hazardous elements in soil, Accumulation in soil, Treatment of contaminated land, Radionuclides in soils and their effects on growth of plants.

7. **Soil erosion and conservation:** Natural erosion, Anthropogenic factors responsible for soil erosion, soil conservation methods.
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SECTION-D


**References**


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ESL967 - Design and Analysis of Experiments

Credits 3-0-0

Time: 3 Hrs.

Max. Marks : 100
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
Strategy of experimentation, Basic principle, Guidelines for designing experiments. Experiments with single factor: ANOVA, Model adequacy checking, Interpretation of results, Use of computers in analysis.

SECTION-B
Randomized complete block design, Latin square design, factorial design, two factor factorial design with design example, Fitting response curve and surfaces, Blocking in factorial design. Two level fractional factorial design: One half fractional $2^k$ design, One-quarter fraction of $2^k$ design, Resolution III, IV, and V designs.

SECTION-C
Fitting regression models: Linear regression models, Estimates of parameters in linear regression models, Hypothesis testing, Confidence intervals, regression model diagnostic, Scaled residuals and PRESS, Testing of lack of fit.

SECTION-D
Response surface methods and process optimization: Method of steepest ascent, Analysis of second order response surface, Mixture experiments, Robust design.

References:
Pre Ph.D. Course in Botany
(Credit Based Evaluation & Grading System)