Bachelor of Statistical Data Science (BSDS)

Course Structure and Syllabus

Curriculum

The course structure for the first four years is given below. The structure for the second year onwards is tentative, and subject to minor changes. Detailed syllabi are provided for the subjects of the first year. Syllabi for the subjects of subsequent years will be published in due course.

First Year

Semester I

- Statistics I: Data Exploration
- Probability I
- Mathematics I
- Introduction to Computing
- Elective (1 out of 3):
  - Biology I — *Prerequisite: No Biology in +2*
  - Economics I — *Prerequisite: No Economics in +2*
  - Earth System Sciences — *Prerequisite: Physics, Chemistry, Mathematics in +2*

Semester II

- Statistics II: Introduction to Inference
- Mathematics II
- Data Analysis using R & Python
- Optimization and Numerical Methods
- Elective (1 out of 3)
  - Biology II — *Prerequisite: Biology 1 or Biology in +2*
  - Economics II — *Prerequisite: Economics I / Economics in +2*
  - Physics — *Prerequisite: Physics in +2*

Second Year

Semester III

- Statistics III: Multivariate Data and Regression
- Probability II
- Mathematics III
- Data Structures and Algorithms
- Statistical Quality Control & OR

Semester IV

- Statistics IV: Advanced Statistical Methods
- Linear Statistical Models
- Sample Surveys & Design of Experiments
- Stochastic Processes
- Mathematics IV

Third Year

Semester V

- Large Sample and Resampling Methods
- Multivariate Analysis
- Statistical Inference
- Regression Techniques
- Database Management Systems

Semester VI

- Signal, Image & Text Processing
- Discrete Data Analytics
- Bayesian Inference
- Nonlinear and Non parametric Regression
- Statistical Learning

Fourth Year

Semester VII

- Time Series Analysis & Forecasting
- Deep Learning I with GPU programming
- Distributed and Parallel Computing
- Electives (2 out of 3):
  - Genetics and Bioinformatics
  - Introduction to Statistical Finance
  - Clinical Trials

Semester VIII

- Deep Learning II
- Analysis of (Algorithms for) Big Data
- Data Analysis, Report writing and Presentation
- Electives (2 out of 4):
  - Causal Inference
  - Actuarial Statistics
  - Survival Analysis
  - Analysis of Network Data

Detailed Syllabus for Semester I Courses

Statistics I: Data Exploration

R should be introduced at the very beginning of the course and should be used to discuss, illustrate and substantiate the lectures through the analysis of suitable data sets.

1. Concepts of population and sample. Intuitive idea about a random sample.

2. Observational studies and randomized studies.

3. Types of data and methods of data collection. Primary and secondary data. Summarization and presentation of different kinds of univariate and bivariate data. Box plots, histograms, empirical c.d.f., Q-Q plots, scatter plots. Bar plots, pie charts.

4. Descriptive measures: Location, dispersion and skewness. Concept of outliers and robust measures. Comparison of various methods.

5. Analysis of bivariate data. Measures of association, correlation and simple linear regression.

6. Categorical data. Cross tabulation. Basic properties. Odds Ratio.

References

1. *Fundamentals of Descriptive Statistics* by Zealure Holcomb.
2. *Statistics* by David Freedman, Robert Pisani and Roger Purves.
3. *The Art of Statistics. How to Learn from Data* by David Spiegelhalter.

Probability Theory I

1. Mathematical set-up for probability, equally likely outcomes, basic counting arguments.

2. Conditional probability, Bayes' rule, independent events.

3. Sampling with and without replacement, Binomial distribution, Normal and Poisson approximations to Binomial distribution.

4. Discrete random variables: Discrete Uniform, Bernoulli, Binomial, Poisson, Hyper-geometric, Geometric distributions.

5. Expectation of a random variable. Variance, standard error, higher moments and generating functions.

6. Discrete joint distributions, independent random variables, repeated trials.

7. Continuous random variables, density, cumulative distribution function, change of variable formula. Expectation, variance and higher moments for continuous random variables. Uniform, Exponential, Gamma, Beta and Normal distribution.

8. Continuous joint distributions, independence. Discrete and continuous conditional distributions and conditional expectations. Covariance and correlation of two random variables. Correlation and independence.

9. Bivariate Normal distribution, density function and basic properties. Marginal and conditional distributions of the coordinates. Spherical invariance of the Bivariate Normal distribution.

10. Distribution of sums, products and quotients for continuous distributions, Student's t, Chi-square and F distributions and their elementary properties.

References

1. *Probability* by J. Pitman
2. *Introduction to Probability Theory* by R. G. Hoel, S. C. Port and C. J. Stone
3. *A First Course in Probability* by S. M. Ross

Mathematics I

One variable calculus

1. Sets: Set operations. Countable and uncountable sets.
2. Functions: injective and surjective functions. Composition of functions. Inverse of a bijective function.
3. Sequences and their limits. Convergent sequences. Cauchy sequences. Series, sum of a series.
4. Catalogue of essential functions (Polynomial, Trigonometric, Exponential, Logarithmic).
5. Limit and continuity of a function. Computation of limits. Properties of continuous functions.
6. Derivative of a function. Derivatives of polynomial, exponential and trigonometric functions. Chain rule.
7. Properties of differentiable functions. Mean Value Theorem, Taylor's theorem. Maxima/minima of a function, L'Hôpital's rule.
8. Riemann integration. Some classes of integrable functions. Rules of Integration: Integration by parts, substitution rule. (Trigonometric integrals. Trigonometric substitution.) Fundamental Theorems of Calculus.
9. Improper Riemann integrals.
10. Sequence of functions: definition and examples.

Linear Algebra

11. Vector spaces, subspaces, linear independence. Basis. Dimension. Sum and intersection of subspaces.
12. Matrices. Elementary row operations. Rank of a matrix. Column space and row space.
13. Operations with partitioned matrices. Trace and determinant of a matrix.
14. Linear transformations, matrix of a linear transformation.
15. Linear equations. Homogeneous and inhomogeneous system of equations. Consistency. Solution space.

References

1. *Linear algebra and its applications* by Gilbert Strang
2. *Introduction to Linear algebra* by Gilbert Strang
3. *Calculus: One-Variable Calculus with An Introduction to Linear Algebra, Vol 1* by Tom Apostol
4. *Calculus and Analytical Geometry* by George B. Thomas and Ross L. Finney

Introduction to Computing

Software Programming / General techniques

1. Introduction to number system: binary, octal, hexadecimal. Introduction to algorithms: Illustration using simple examples (Euclid's algorithm, bisection method, regula falsi). Representation of numbers and data types: Signed and unsigned integers, floating points, overflow, underflow.

2. Imperative programming: Introduction, common syntax and constructs— variables, assignment, expressions, conditionals and branching, iteration. Input / output. Functions: parameter passing, call by value, call by reference, recursion. Illustration using C / R / Python / Javascript (basic similarities and differences).

3. Arrays. Illustration using sorting.

4. Pointers, structures, dynamic allocation.

5. Data Structures: Queue, Stack, Linked lists, Trees.

6. Basic ideas of Object-oriented programming: Introduction to classes, inheritance, overloading, polymorphism.

Software/hardware/Software-hardware interface

7. Introduction to digital computers: CPU, main memory, peripherals, I/O devices, storage.

8. Random access machine model of computing. Basic concepts of formal run-time analysis.

9. Basic ideas of parallel programming.

10. Memory management strategies: C (dynamic allocation / free) vs R / Python (garbage collection)

Algorithms

11. Introduction to error analysis: round-off errors, floating point operations, error propagation, condition number and stability. Illustration using simple examples.

References

1. *C++ How to Program* by Paul Deitel and Harvey Deitel
2. *Introduction to Numerical Analysis* by Josef Stoer and Roland Bulirsch

Earth System Sciences/Geosciences

Prerequisite: Physics, Chemistry and Mathematics in +2

1. The Earth System: The Scientific Method; System Concept, Dynamic Interactions among Systems, The Energy Cycle, Introduction to Geological data
2. Earth as a Planet in the Solar System: Origin of the Universe and the Solar System, Evolution of the Planets, Meteorites and Asteroids, Origin of Atmosphere, Ocean and Life
3. The Solid Earth: The Earth as a Layered Planet: Mechanical Layering of the Earth, Layers of Different Composition and Physical State, Earthquake and the Earth's Interior, Plate Tectonics, Geothermal Gradient, Magmas and Volcanoes
4. The Earth's Evolving Crust: Sedimentary Strata; Sedimentary process and Sedimentary Rocks; Metamorphism and Metamorphic Rocks; Plate Tectonics, Continental Crust and Mountain Building; Understanding the past from Stratigraphic Records; Geological Time Scale
5. Hydrosphere, Atmosphere and Biosphere: Water and the Hydrologic Cycle; Snow and Ice; The Oceans; The Atmosphere; Winds and the Global Air Circulation; The Earth's Climate System and the Changing Climate
6. Life on Earth: A Planetary Perspective on Life; The Habitable Planet; Biogeochemical Cycles and Biological Evolution; Mass Extinctions
7. Resources on Earth: Coal and Petroleum Resources; Nuclear, Wind and Hydroelectric Power Energy
8. Geostatistics: Application of statistics to Geological Data; Pattern recognition of geological events; Statistics for earth resources.

References

1. *The Blue Planet – An Introduction to Earth System Science* by B.J. Skinner, S.C. Porter and D.B. Botkin
2. *The Earth Machine – The Science of a Dynamic Planet* by E.A. Mathez and J.D. Webster
3. *Understanding Earth, 5th Edition* by J. Grotzinger, T.H. Jordan, F. Press and R. Siever
4. *Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment* by C. Emiliani

Economics I: Introduction to Economics

Only if no Economics in +2

Micro Economics

1. Welfare Economics: Supply and Demand, Elasticity
2. Consumption and Consumer behaviour
3. Production and Theory of costs.
4. Market Organisation: Competition, Monopoly.

Macro Economics

5. National income accounting, demand and supply.
6. Simple Keynesian model and extensions.
7. Consumption and Investment.
8. Inflation and Unemployment.
9. Fiscal policy.
10. Money, banking and finance.

References

1. *Intermediate Microeconomics* by Hal Varian.
2. *Microeconomic Theory* by Richard Layard and A.A. Walters
3. *Microeconomics in Context* by N. Goodwin, J. Harris, J. Nelson, B. Roach and M. Torras
4. *Microeconomics: behavior, institutions, and evolution* by S. Bowles
5. *Macroeconomics* by N. G. Mankiw.
6. *Macroeconomics* by R Dornbusch and S Fisher

Biology I

Only if no Biology in +2

1. Biological classification of living organisms: Distinguishing characteristics of living and non-living things; Definition and concept of Biodiversity; Need for classification; Three domains of life; Concept of species and taxonomical hierarchy; Binomial nomenclature. Five kingdom classifications; classification of plants; classification of animals

2. Cell and cell division: Study of cell structure and functions; Mitosis and Meiosis, comparative account of mitosis and meiosis. Cell theory and cell as the basic unit of life, structure of prokaryotic and eukaryotic cells; Plant cell and animal cell; Cell envelope; Cell membrane, Cell wall. Chemical constituents of living cells: biomolecules, structure and function of proteins, carbohydrates, lipids, nucleic acids; Enzymes- types, properties, enzyme action; Cell cycle, mitosis, meiosis and their significance

3. Central dogma: Structure and function of DNA and RNA; Replication, transcription, translation.

4. Basic biochemistry: Metabolism of protein, carbohydrate and fat.

5. Basic microbiology: Microbial culture medium. Microbial morphology, growth and development. Applications of microbiology.

6. Basic agriculture: Plant, soil and environment interaction. Major agricultural and horticultural crops of India. Pest and diseases of crop plants.

7. Plant Physiology: Photosynthesis: Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways. Respiration and photorespiration: Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway. Nitrogen metabolism: Nitrate and ammonium assimilation; amino acid biosynthesis.

8. Animal Physiology: Digestive system. Cardiovascular System. Respiratory system. Nervous system. Sense organs: Vision, hearing and tactile response. Excretory system.

References

1. *Instant Notes on Biochemistry*, B D Hames, N M Hooper, J D Houghton, Viva publications
2. *Instant Notes on Genetics*, P C Winter, G I Hickey and H L Fletcher, Viva Publication
3. *Principles of Genetics*, D P Snustad and M J Simmons, John Wiley & Sons Inc
4. *Biochemistry*: U Satyanarayana and U Chakrapani
5. *Plant Physiology, Development and Metabolism*, Satish C Bhatla and Manju A. Lal, Springer.
6. *Textbook of Animal Physiology,* P.B.Reddy
7. *Biochemistry*, Lehninger
8. *Microbiology*, Pelczar MJ and Krein NR
9. *Principles and methods in landscape ecology*, Almo Farina.
10. *Microbiology: Concepts and Applications*, Michael Pelczar, Jr., ECS Chan, Noel R. Krieg, McGraw Hill Education; 5th edition
11. *General Microbiology*, R.P. Singh, Kalyani Publishers
12. *Microbiology*, Lansing Prescott, J.P. Harley, D.A. Klein, Brown (William C.) Co, U.S.; 2nd edition
13. *Microbiology Fundamentals and Applications* (7th Ed.), S.S. Purohit, Agrobios
14. *Environmental Science*, S. C. Santra, New Central Book Agency
15. *Environmental Science: A comprehensive Treatise on Ecology and Environment*, Sovan Roy, Publishing Syndicate, Calcutta

Detailed Syllabi for Semester II Courses

Statistics II: Introduction to Inference

Methods will be motivated through real-life examples. Performance of statistical procedures will be assessed through numerical simulations.

1. Population vs. sample. Empirical distribution. Parametric statistical models. Need for inference on a parameter.
2. Point estimation: Concept of bias, variance, mean squared error (MSE), relative efficiency.
3. Estimation of parameters by method of moments and maximum likelihood method.
4. Sampling distributions derived from normal populations: Chi-square, t and F distributions. (Discussion of properties without derivation).
5. Introduction to asymptotic inference: Informal discussion of Weak Law of Large Numbers and Central Limit Theorem. Consistency of estimators. Approximating sampling distributions through CLT.
6. Numerical computation of sampling distributions based on independent samples from an arbitrary population. Comparison with CLT-based approximations.
7. Hypothesis testing: Null and alternative hypotheses, simple and composite hypotheses, Type I and Type II errors, level and power of a test, p-value. Neyman-Pearson Lemma, most powerful tests, unbiased tests.
8. Exact and large sample tests for binomial proportion and mean of a normal distribution (one sample case). One-sided and two-sided alternatives.
9. Exact (pooled-t) and large sample tests for the equality of two normal means. Paired t-test. Test for equality of variances of two normal populations. Test for the equality of two binomial proportions.
10. Interval estimation: Construction using pivotal quantities and critical regions. Exact and large sample confidence intervals. Confidence intervals for binomial, normal and Poisson parameters (one sample case).
11. Large sample confidence intervals for the difference of two binomial proportions. Exact and large sample confidence intervals for the difference of means of two normal populations.
12. Sample size determination in tests of hypotheses for ensuring a specified power, and in constructing confidence intervals for ensuring a specified interval width.

References

1. *Statistics* by D. A. Freedman, R. Pisani and R. Purves.
2. *The Art of Statistics: How to Learn from Data* by D. Spiegelhalter.
3. *All of Statistics: A Concise Course in Statistical Inference* by L. Wasserman.
4. *Probability and Statistics* by M. H. DeGroot and M. J. Schervish.
5. *Mathematical Statistics with Applications* by D. Wackerly, W. Mendenhall, R. L. Scheaffer.

Mathematics II

Calculus (9 weeks)

1. Infinite Series. Alternating Series. Absolute Convergence. Tests of convergence: comparison test, root test, ratio test, integral test.
2. Power Series: Radius of convergence of a power series. Differentiation/integration of power series. Revisit Trigonometric functions, Exponential Functions and Logarithms.
3. Functions of Several Variables. Limits and Continuity.
4. Partial Derivatives, directional derivatives. Differentiability. Differentiability of functions with continuous partial derivatives. Jacobian and Chain rule.
5. Matrix differentiation with examples.
6. Maximum and minimum values. Hessian matrix. Multivariate Taylor series.
7. Multiple Integrals as iterated integrals. Change of variables in multiple integrals. Jacobian formula.

Linear Algebra (5 weeks)

8. Orthogonality and its geometric interpretation.
9. Eigenvalues and eigenvectors. Spectral decomposition. Singular value decomposition (SVD).
10. Positive semidefinite matrices. Projection matrices.
11. Matrix norms, and low rank matrix approximation using SVD.
12. Computations using matrices: QR decomposition, Gram-Schmidt orthogonalization, Cholesky decomposition.

References

1. *Linear algebra and its applications* by Gilbert Strang
2. *Introduction to Linear algebra* by Gilbert Strang
3. *Calculus: One-Variable Calculus with An Introduction to Linear Algebra, Vol 1* by Tom Apostol
4. *Calculus: Multi-Variable Calculus and Linear Algebra with Applications to Differential Equations and Probability, Vol 2* by Tom Apostol

Optimization and Numerical Methods

Focus will be on methods and applications. Relevant mathematical results will be stated without proof. Selected optimization methods will be implemented in R, Python or Julia.

Optimization

1. Role of optimization in Data Science/Statistics through motivating examples (e.g., least squares and maximum quasi-likelihood methods in linear/generalized linear models, support vector machine, penalized regression, matrix approximation).

2. Basics of convex optimization: Overview of convex sets and convex functions. Convexity preserving operations. Notions of convex hull, cone, polyhedra.

3. Optimization problems: Convex vs. non-convex optimization. Constrained vs. unconstrained optimization. Global and local optima.

4. Optimality conditions: First and second order optimality conditions. Primal and dual problems. Method of Lagrange multiplier. KKT condition.

5. Introduction to Linear Programming with examples.

6. Introduction to Quadratic Programming with examples.

7. Introduction to Gradient-based methods with examples.

8. Introduction to Second order methods with examples.

Numerical Methods

9. Numerical solution of nonlinear equations in one variable: Bisection and Newton-Raphson methods.

10. Basic concepts of interpolation. Polynomial interpolation.

11. Introduction to Numerical integration with examples.

References

1. *Convex Optimization: Algorithms and Complexity* by S. Bubeck.
2. *Convex Optimization* by S. Boyd and L. Vandenberghe.
3. *Numerical Optimization* by J. Nocedal and S. Wright.
4. *Modern Optimization* with R by P. Cortez.
5. *Julia Programming for Operations Research* by C. Kwon.
6. *Linear Algebra and Learning from Data* by G. Strang.
7. *Elementary Numerical Analysis: An Algorithmic Approach* by S. D. Conte and C. de Boor.

Data Analysis Using R and Python

1. The REPL model for R and Python. IDEs such as RStudio and Jupyter.
2. Vectors (arrays) in R and Python (through numpy). Indexing. Other data types: Lists, data frames, dictionaries. Operators and functions, attributes. Using the help system.
3. Objects, workspace, add-on packages. Data import and export. Excel / CSV, native file formats. Common data manipulation and summary operations in R; base packages and dplyr. Scoping rules.
4. Probability calculations and simulation. Data visualization. Basic statistical modeling, formula interface.
5. Dynamic documents and notebooks. Illustration using knitr and related packages in R. Exporting as PDF / HTML reports.
6. Working simultaneously with multiple languages. Calling C / C++ / Python from R (Rcpp, reticulate).

References

1. *Introductory Statistics with R* by Peter Dalgaard
2. *R for Data Science* by Hadley Wickham and Garrett Grolemund
3. *Python Data Science Handbook* by Jake Vanderplas
4. *Python for Data Analysis* by Wes McKinney

Physics

Prerequisite: Physics in +2

1. Thermodynamics (Zeroth to Third Laws), Carnot Engines, Heat Equations, Various thermodynamic potentials, Relations (Requires partial derivatives, multivariable extrema)
2. Equilibrium Statistical mechanics: The microcanonical, Canonical and Grand Canonical Ensembles; Ideal Classical Gas from Statistical Mechanics; Applications of the three ensemble formulations (spin systems, gases, etc: preferably should include a fairly detailed investigation of Ising Model in d=1 and 2 with introduction of mean-field theory)
3. Classical Equilibrium Phase Transitions: Gibbs phase rule, Classification of phase transitions, Clausius-Clapeyron Equations, Rankine Cycles, etc.; Scaling ideas, Widom's scaling hypothesis, continuous phase transitions, critical exponents, calculation of critical exponents from mean-field theory in suitable systems
4. Basics of Renormalization Group: Kadanoff's block spin transformation/coarse graining, Exposition of various concepts (dimensional analysis for scaling, relevant, marginal and irrelevant operators, fixed points and their stabilities, RG flow diagrams, corrections to critical exponents etc.) through simple problems, universality

5. Random systems: annealed and quenched disorder, Harris criterion, introduction to spin glasses and Replica method, perturbative approach to random fixed point, introduction to percolation
6. Computer Simulations in Classical Statistical Mechanics: Monte Carlo simulations, Molecular and particle dynamics.

References

1. *Statistical Physics of Particles* by Mehran Kardar
2. *Statistical Physics of Fields* by Mehran Kardar
3. *Statistical Mechanics* by Pathria and Beale
4. *Thermodynamics and an Introduction to Thermostatistics* by Herbert Callen
5. *Lectures on Phase Transitions and the Renormalization Group* by Nigel Goldenfeld
6. *Statistical Mechanics: Entropy, Order Parameters, and Complexity* by James P. Sethna
7. *Scaling and Renormalization in Statistical Physics* by John Cardy
8. *A Guide to Monte Carlo Simulations in Statistical Physics* by David P. Landau, Kurt Binder

Economics II: Economic data

Prerequisite: Either Economics 1 or Economics in +2

1. Index numbers: Construction of index numbers, properties, some well-known index number formulae, problem of construction of index numbers, chain indices, cost of living indices, splicing of index numbers, different types of index numbers used in India.
2. Analysis of income and allied size distributions: Pareto and log-normal distributions, genesis, specification and estimation, Lorenz curve, Gini coefficient.
3. Demand analysis: Classification of commodities, Engel curve analysis using cross-section and time series data, Engel curves incorporating household characteristics, demand projection, specific concentration curves.
4. Production analysis: Profit maximization, cost minimization, returns to scale, Cobb-Douglas and ACMS production functions.
5. International Statistical system: Overview on Sectoral statistics and other economic Statistics: Standard International classifications used for compilation of economic statistics – International Standard Industrial Classification (ISIC Rev. 4), Administrative data, Business Registers Overview of Sectoral Statistics: Agriculture, forestry, fisheries; Mining, Manufacturing, Energy & construction, Domestic Trade and Transport, Banking, insurance, financial statistics, Government finance statistics, and Services sector statistics. Employment & Labour, Prices, Merchandise trade statistics and Statistics on International Trade in Services, System of National Accounts.
6. Measurement of vital rates: SRS, Life table, Literacy rate, etc.
7. Statistics of Production: agriculture and industry, annual survey of industries, index of industrial production.

8. Price Statistics, consumer price index numbers.

9. Income and consumer expenditure distribution, poverty.

10. Employment and unemployment.

References

1. *Statistics for Economists,* P.H. Karmel and M. Polasek.
2. *Price Index Numbers,* R.G.D. Allen.
3. *Income Inequality and Poverty,* N. Kakwani.
4. *An Introduction to Econometrics,* L.R. Klein.
5. *Empirical Econometrics*, J.S. Cramer.
6. *Econometric Models, Techniques and Applications,* M.D. Intrilligator.
7. *Indian Official Statistical Systems,* M.R. Saluja.
8. *Living Standard Measurement Surveys*, World Bank
9. *National Accounts: A Practical Introduction*. United Nations, New York, 2003
10. *Business Registers -Recommendations Manual*. EUROSTAT, 2010
11. *International Standard Industrial Classification of All Economic Activities*, Revision 4. United Nations, New York, 2008.
12. *Classifications of Expenditure according to Purpose*. United Nations, New York, 2000.
13. *International Recommendations for Industrial Statistics.* United Nations, New York, 2008.

Biology II

Prerequisite: Either Biology I or Biology in +2

1. Predator-prey interaction: Definitions, relationships and population dynamics, Evolution and examples.

2. Principles of genetics: Definition of gene and genetic code; relationship between them. Mendel's Law of genetics and application in human population. Interaction of Genes or Factor Hypothesis: Introduction; incomplete dominance or blending inheritance; lethal factor; simple interaction or two factor pairs affecting the same character; epistasis — complementary factor; supplementary factor; inhibitory factor; duplicating factor or multiple factor; polymerisms. Sex Chromosome and Sex-Linkage: Sex chromosomes; sex-linkage or sex-linked inheritance or inheritance related to sex. Cytoplasmic Inheritance or Extranuclear inheritance: Introduction; maternal effect; extranuclear inheritance.

3. Landscape ecology: Introduction to landscape ecology framework. Scaling patterns and processes across landscapes. Landscape heterogeneity and disturbances. Principles of landscape dynamics. Methods in landscape ecology.

4. Environmental science: Components of environment, Environmental pollution and management, Climate change and global warming, Environmental quality analysis.

References

See references for Biology I