Harmonized Curriculum for the B.Sc. Degree Program in Statistics

Ethiopia

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1. Introduction

For about a half of a century, Addis Ababa University was the only Higher Education Institution (HEI) responsible for Statistics education in the country. Currently, with intensive expansion of HEIs several young universities have initiated Bachelor of Science (B.Sc.) programs in Statistics to meet the need for qualified statisticians in the growing socio-economic development of the country.

In 2007/08 a joint effort was made by concerned public Universities to develop a curriculum for a four-years B Sc degree program in Statistics. However, with the need to develop a harmonized and an international standard curriculum for a three-years B.Sc. degree program in Statistics, a national level team consisting of highly qualified statisticians was formed in July 2008 with the task to come up with the intended curriculum.

In an effort to harmonize and standardize the curriculum, a critical review of the list of course requirements, course descriptions, course outlines, textbooks, reference materials and modes of delivery of courses in the existing Statistics curriculum of nine universities was made. In addition to this, the team carried out an intensive internet search to review international experience and standards of B.Sc. Statistics curriculum. Particularly, a study of course requirements, course descriptions, textbooks, reference materials, mode of delivery, and teaching facilities of the Bologna process and other international universities was considered and relevant experience gained.

The draft curriculum was enriched at a national workshop organized by the Higher Education Strategy Centre held in Addis Ababa from August 24-26, 2009. The participating universities were: Addis Ababa, Arbaminch, Axum, Bahr-Dar, Dilla, Dire-Dawa, Gondar, Haramaya, Hawassa, Jijiga, Jimma, Madawalabu, Mekelle, Mizan-Teppi, Samera, Wellega and Wollo. After incorporating all constructive comments the team of experts has finally come up with this harmonized curriculum.

2. Objectives of the Program

2.1 General Objective

To train middle level statisticians in order to meet the demands of the socio-economic, business and development sectors in the country.

2.2 Specific Objectives

- To train middle level statisticians who can serve in collecting, processing and analyzing statistical data;
- To train middle level statisticians who can assist in statistical research undertakings and provision of statistical services.
- To produce middle level statisticians who can manage and supervise the activities of statistical units or offices at both government and nongovernmental organizations;
- To produce potential candidates for graduate studies so as to meet the demand for high level statisticians who can teach and conduct research at HEIs, and other research and training centers.

3. Rationale for Harmonization of the Curriculum

Curriculum is dynamic by its nature and that it needs to be relevant to address new cultural, societal and technological developments at national and international levels. It is, therefore, of importance to concerned institutions to constantly revise the curricula of their academic programs to meet societal needs and developments. This being the general objective of any curriculum change or revision, it was also in recognition of the fact that many young universities in the country with limited experience and human resources require support in the effort to develop a standardized curriculum.

Accordingly, it is believed to develop a harmonized national level curriculum by experienced and senior professionals in the area that envisages international standards and experience. By doing so, it is possible for the Federal Government of Ethiopia and the Ministry of Education in particular to wisely allocate necessary resources to equip the required teaching learning facilities (Textbooks, Reference materials, Computer labs, Statistical Software, etc) for the implementation of the curriculum.

4. Graduate Profile

A B.Sc. graduate in Statistics is expected to

- demonstrate competence in data collection, management, summary and analysis required at many production and development sectors day to day activities,
- supervise and/or manage activities of lower level statistical units or offices,
- assist in statistical research and the provision of statistical services in research establishments, business and government and non-government institutions,
- plan and conduct sample surveys and experimental designs,
- use statistical software to carry out necessary computation for statistical analysis of data,
- write clear statistical reports and communicate the results of statistical analyses in non-technical language,
- demonstrate professional ethics in his/her career,
- contribute to the ongoing development of the country in his/her area with sense of responsibility, and
- demonstrate social responsibility and capacity to manage teamwork.

5. Program Requirements

5.1 Admission Requirement

An applicant must have successfully completed the science preparatory in a recognized secondary school with good performance in mathematics in the national or equivalent placement/entrance examination or the applicant must have graduated from a recognized university/college with a diploma in Statistics or related fields.

5.2 Graduation Requirement

A student must take a total course load of at least 108 credit hours and achieve a CGPA of at least 2.00 in Statistics and overall CGPA of at least 2.00 with no “F” grade in any of the courses taken.

6. Duration of Study

The duration of the study is three years.

7. Degree Nomenclature

English: Bachelor of Science Degree in Statistics

Amharic: የሳይንስ ባቸሎር ዲግሪ በስታቲስቲክስ

8. Teaching and Learning Methods and Facilities

8.1 Teaching Methods

- Normally courses shall be delivered with a combination of
  - Lectures, power-point presentation, blackboard/whiteboard, etc;
  - Tutorials;
  - discussions and demonstrations;
  - computer laboratory work using statistical software;
  - practical research work and
  - group and individual assignment and exercises.
- Most Statistical courses require students to do statistical analyses both manually and using statistical software.

8.2 Facilities and Materials

Textbooks and References

- Each course requires textbook(s) and reference materials and the Department is responsible to make available the identified textbooks and references;
- Students are encouraged to have copies of the textbook(s);
- Enough number of copies of textbooks and reference materials should be available at the University Libraries and Department book stores;
- Course outlines should be available for students;
- Textbooks and references should be kept up-to-date by the Department; however, a textbook and defined course outline should be strictly followed.

Computer Labs for Statistics

- Well-equipped computer labs should be organized with quite good number of computers and internet connections;
- Popular statistical software such as MINITAB, R, SPSS and SAS should be installed to be utilized by students for statistical computation, simulation and analysis;
- Proper management of the labs and updating mechanism are required.

Classroom Facilities

Classrooms would be equipped with PC, LCD, overhead projector, blackboard, whiteboard and network to facilitate the teaching-learning process.

9. Mode of Assessment and Evaluation

9.1 Assessment Methods

The assessment method includes a combination of tests and assignments, presentations, Computer lab practices, practical projects, mid-semester and final examination.

9.2 Grading Systems

The grading system can be established by the pertinent Department/University.

10. Quality Assurance

In order to assure the quality of the Statistics B. Sc. program the following efforts shall be made by the Department and University as appropriate.

- The teaching and learning methods and facilities defined in Sections 8.1 and 8.2 are consistently implemented;
- Course lectures are delivered by a staff member with a minimum academic rank of lecturer. Only in special cases would an academic staff with the rank of assistant lecturer undertake responsibility to teach a course if the Department officially declares the competency of the assistant lecturer;

- Students' evaluation about the performance of an instructor is positively considered to improve the teaching learning environment;
- The examination committee of the Department evaluates and approves examination standards and grade scales;
- Feedback from graduates, employers and other stakeholders are driving forces to improve the curriculum;
- The teaching facilities and materials are reviewed on regular basis;
- External audit of the performance of the Department by professionals assigned by the University should be regularly carried out as a basis for corrective measures.

11. Course Coding Scheme

Stat:	Field of study: Statistics
1st digit:	Level of course: 2 - 4
2nd digit:	Discipline:
	7: a course on theory or fundamentals of statistics
	8: an applied course
	9: a specialized course
3rd digit:	Odd: a 1st semester course
	Even: a 2nd semester course
	Zero: any semester

12. Course Requirement

12.1 Compulsory Statistics Courses

Course Code	Course Title	Lecture	Tut+Lab	Credit Hours
Stat 271	Basic Statistics	3	1	3
Stat 272	Statistical Methods	3	2	3
Stat 275	Introduction to Probability Theory	3	2	3
Stat 372	Sampling Theory	4	1	4
Stat 373	Statistical Computing I	2	3	3
Stat 374	Statistical Computing II	2	3	3
Stat 376	Design and Analysis of Experiments	4	2	4
Stat 377	Demography	3	1	3
Stat 378	Time Series Analysis	4	2	4
Stat 379	Regression Analysis	3	2	3
Stat 471	Statistical Theory of Distributions	3	2	3
Stat 472	Statistical Inference	3	2	3
Stat 474	Introduction to Multivariate Methods	3	1	3
Stat 476	Categorical Data Analysis	3	1	3
Stat 477	Econometrics	3	1	3
Stat 479	Statistical Quality Control	3	1	3
Stat 485	Sampling Practice			2
Stat 487	Project I: Statistical Consultancy and Research Methods			2
Stat 488	Project II: Senior Research in Statistics			2
Total				**57**

12.2 Elective Statistics Courses

A minimum of 9 credit hours must be taken from the followings list:

Course Code	Course Title	Lecture	Tut+Lab	Credit Hours
Stat 478	Operations Research	3	1	3
Stat 486	Introduction to Statistical Modeling	2	3	3
Stat 491	Social and Economic Statistics	3		3
Stat 493	Biostatistics and Epidemiology	3		3
Stat 494	Actuarial Statistics	3		3
Stat 496	Applied Spatial Statistics	3		3
Stat 497	Statistical Ecology	3		3

12.3 Supportive Courses

Course Code	Course Title	Lecture	Tut/Lab	Credit Hours
Mathematics				
Math 264	Calculus I	4	2	4
Math 325	Linear Algebra I	3	2	3
Math 326	Linear Algebra II	3	2	3
Math 335	Calculus for Statistics	3	2	3
Math 339	Numerical Methods for Statistics	3	2	3
Computer Science				
Comp xxx	Introduction to Computer Science	3	2	3
Comp xxx	Fundamentals of Programming	3	2	3
Comp xxx	Fundamentals of Database Systems	3	2	3

Economics				
Econ xxx	Introduction to Economics	3		3
Econ xxx	Introduction to Microeconomics	3		3
Econ xxx	Introduction to Macroeconomics	3		3

12.4 General Education Courses

Course Code	Course Title	Credit Hours
Xxx	English Writing Skills	3
Xxx	Communicative English Skills	3
Xxx	Civics and Ethical Education	3
Total		**9**

12.5 Summary of Credit Requirements

Statistics		Supportive	General Education	Total Credit Hours
Compulsory	**Elective**			
57	**9**	**34**	**9**	**109**

13. Course Sequencing and Scheduling

Year I Semester I

Course Code	Course Title	Credit Hours	Lect.	Tutorial + Comp. Lab	Prerequisite
Stat 271	Basic Statistics	3	3	1	
Stat 275	Introduction to Probability Theory	3	3	2	
Math 264	Calculus I	4	4	2	
Math 325	Linear Algebra I	3	3	2	
Comp xxx	Introduction to Computer Science	3	3	2	
Xxx	Communicative English Skills	3	3		
Total		**19**			

Year I Semester II

Course Code	Course Title	Credit Hours	Lect.	Tutorial + Comp. Lab.	Prerequisite
Stat 272	Statistical Methods	3	3	2	Stat 271, Stat 275
Math 335	Calculus for Statistics	3	3	2	Math 264
Math 326	Linear Algebra II	3	3	2	Math 325
Comp xxx	Fundamentals of Programming	3	3	2	
Econ xxx	Introduction to Economics	3	3		
Xxx	English Writing Skills	3	3		
Total		**18**			

Year II Semester I

Course Code	Course Title	Credit Hours	Lect.	Tutorial+ Comp. Lab	Prerequisite
Stat 379	Regression Analysis	3	3	2	Stat 272
Stat 373	Statistical Computing I	3	2	3	
Stat 377	Demography	3	3		
Math 339	Numerical Methods for Statistics	3	3	2	Math 264, Math 325
Comp xxx	Fundamentals of Database Systems	3	3	2	
Econ xxx	Introduction to Microeconomics	3	3		
Total		**18**			

Year II Semester II

Course Code	Course Title	Credit Hours	Lect.	Tutorial + Comp. Lab.	Prerequisite
Stat 376	Design and Analysis of Experiments	4	4	2	Stat 272
Stat 372	Sampling Theory	4	4	1	Stat 272
Stat 378	Time Series Analysis	4	4	2	
Stat 374	Statistical Computing II	3	2	3	Stat 373
Econ xxx	Introduction to Macroeconomics	3	3		
Total		**18**			

Year III Semester I

Course Code	Course Title	Credit Hours	Lect.	Tutorial + Comp. Lab	Prerequisite
Stat 471	Statistical Theory of Distributions	3	3	2	Stat 275
Stat 485	Sampling Practice	2			Stat 372
Stat xxx	Elective	3			
Stat 477	Econometrics	3	3	1	
Stat 479	Statistical Quality Control	3	3	1	
Stat 487	Project I: Statistical Consultancy and Research Methods	2			Stat 376, Stat 378, Stat 379
xxx	Civics and Ethical Education	3			
Total		**19**			

Year III Semester II

Course Code	Course Title	Credit Hours	Lect.	Tutorial + Comp. Lab	Prerequisite
Stat 472	Statistical Inference	3	3	2	Stat 471
Stat xxx	Elective	3	3		
Stat xxx	Elective	3	3		
Stat 476	Categorical Data Analysis	3	3	1	
Stat 474	Introduction to Multivariate Methods	3	3	1	
Stat 488	Project II: Research Project in Statistics	2			Stat 487
Total		**17**			

14. Course Description and Outline

14.1 Compulsory and Elective Courses

Course title: **Basic Statistics**
Course code: **Stat 271**
Credit hours: **3**
Contact hours: **Lecture 3 hours and Tutorial 1hour per week**
Pre-requisite:

Course description
History of statistics, Meaning of statistics; Methods of data collection; Methods of data presentation; Measures of location; Measures of variation; Moments, skewness and kurtosis; Sampling techniques; Simple linear regression, correlation and rank correlation.

Objectives

- to introduce students to the basic statistical knowledge on data collection and presentation methods, measures of central tendency and variation, regression and correlation;
- to demonstrate the importance and usefulness of statistics in real life and on real data;
- to show how to present data informatively and clearly;
- to build up interest in statistics and hence encourage students to study the subject further.

Learning outcomes
At the end of the course students are expected to:

- have a broad knowledge of the basic understanding of statistical techniques demonstrated through principles of data collection, descriptive statistics, linear regression, correlation, computation and data analysis;
- identify different techniques of sampling and understand the methods of data collection, organization, presentation, analysis and interpretation;
- differentiate among common types of data, and summarize and display them appropriately;
- learn some desirable properties of averages and measures of variation;
- have basic skills in exploratory data analysis and problem solving.

Course Outline

1. Introduction (4 lecture hours)

1.1 History and development of Statistics
1.2 Definition and classification of Statistics
1.3 Stages in statistical investigation
1.4 Definition of some basic terms
1.5 Applications, uses and limitations of Statistics

1.6 Types of variables and measurement scales

2. Methods of Data Collection and Presentation (6 lecture hours)

2.1 Methods of data collection

2.1.1 Sources of data

2.1.2 Types of data

2.1.3 Methods of collection

2.2 Methods of Data Presentation

2.2.1 Motivating examples

2.2.2 Frequency distributions: qualitative, quantitative: absolute, relative, percentage, cumulative

2.2.3 Tabular presentation of data

2.2.4 Diagrammatic display of data: Bar charts, Pie-chart, Cartograms

2.2.5 Graphical presentation of data: Histogram, Frequency Polygon, Ogive Curves

3. Measures of Central Tendency (12 lecture hours)

3.1 Motivating examples

3.2 Objectives of measures of central tendency

3.3 Summation notation

3.4 Important characteristics of a good average

3.5 Mean

3.5.1 Arithmetic Mean

3.5.2 Geometric Mean

3.5.3 Harmonic Mean

3.6 Median

3.7 Mode

3.8 Measures of location (Quantiles): Quartiles, Deciles, Percentiles

4. Measures of Variation (Dispersion), Skewness and Kurtosis (12 lecture hours)

4.1 Motivating examples

4.2 Objectives of measures of variation

4.3 Measures of Dispersion (Variation)

4.3.1 Range and Relative Range

4.3.2 Quartile Deviation and Coefficient of Quartile Deviation

4.3.3 Mean Deviation and Coefficient of Mean Deviation

4.3.4 Variance, Standard Deviation and Coefficient of Variation

4.3.5 Standard Scores

4.4 Moments (about the origin and about the mean)

4.5 Skewness

4.6 Kurtosis

5. Sampling Techniques (6 lecture hours)

5.1 Basic concepts: population, sample, parameter, statistic, sampling frame, sampling unit, sampling error, sample size

5.2 Reasons for sampling

5.3 Types of errors

5.4 Types of sampling

5.4.1 Probability versus non-probability Sampling Techniques

5.4.2 Purposive Sampling
5.4.3 Simple random sampling
5.4.4 Method of selecting a simple random sample: lottery method, table or computer generated random numbers)
5.4.5 Systematic sampling
5.4.6 Stratified sampling
5.4.7 Cluster sampling

6. Simple Linear Regression and Correlation (8 lecture hours)

6.1 Motivating examples
6.2 Definition: regression and correlation
6.3 Simple linear regression
6.4 Covariance and Coefficient of Correlation
6.5 Rank Correlation

Textbook

Bluman, A.G. (1995). Elementary Statistics: A Step by Step Approach (2nd edition). Wm. C. Brown Communications, Inc.

References

1 Coolidge, F.L.(2006). Statistics: A Gentle Introduction (2nd edition).
2 David, S.M., McCabe, P. and Craig, B. (2008). Introduction to the Practice of Statistics (6th edition). W.H. Freeman.
3 Eshetu Wencheko (2000). Introduction to Statistics. Addis Ababa University Press.
4 Freund, J.E and Simon, G.A. (). Modern Elementary Statistics (9th Edition).
5 Gupta, C.B. and Gupta, V. (2004). An Introduction to Statistical Methods. Vikas Publishing House, Pvt. Ltd, India.
6 Moore, D. S. (2007). The Basic Practice of Statistics (4th edition). W.H. Freeman and Company.
7 Ross, S. M. (2005). Introductory Statistics (2nd edition). Elsevier Academic Press.
8 Snedecor, G.W and Cochran, W.G. (1980). Statistical Methods (7th edition).
9 Spiegel, M.R. and Stephens, L.J. (2007). Schaum's Outline of Statistics, Schaum's Outline Series (4th edition). McGraw-Hill.
10 Weiss, N. A. (2008). Introductory Statistics (8th edition). Pearson Education, Inc..

Teaching and learning methods

Lectures, tutorials, discussions, demonstrations and assignments.

Mode of Assessment

Two or more tests and assignments	20%
Mid-Semester Examination	30%
Final Examination	50%
Total	100%

Course title: **Statistical Methods**
Course code: **Stat 272**
Credit hours: **3**
Contact hours: **Lecture 3 hour per week, Tutorial and Computer Lab 2 hours per week**
Pre-requisite: **Stat 271 and Stat 275**

Course description
Statistical estimation and the concept of hypothesis testing; Sampling distribution of the mean, Variance, Proportion, Difference between means, Difference between proportions and ratio of variances; Inference about the mean, variance and proportion (confidence interval and hypothesis testing); Comparison of two sample means, proportions and ratio of variances; Paired versus independent sample comparisons; Sample size in comparative studies; One-way ANOVA and Fisher's least significant difference; Chi-square tests of association; Non-parametric methods.

Objectives
- to introduce students to the fundamental statistical methods for data analysis;
- to introduce students to an intermediate knowledge of statistical methods and a variety of applications of statistical inference in different situations including comparison of means, proportions, and standard deviations, non-parametric or distribution-free tests and introduction to analysis of variance;
- to demonstrate the importance and usefulness of the above concepts in real applications;
- to enable students to understand both the strengths and weaknesses of the hypothesis test approach to statistical analysis;
- to introduce students to non-parametric tests purpose of statistical inference;
- to equip students with applications of statistical ideas to solve problems from a wide range of disciplines;
- to train students to communicate the results of their analyses in clear non-technical language;
- to inculcate interest in Statistics and encourage students to study more advanced courses.

Learning outcomes
At the end of the course students are expected to:
- understand the difference between paired and independent data, and be able to recognize both in practice;
- understand the framework of hypothesis testing for carrying out statistical inference and know what is meant by the null and alternative hypothesis, test statistic, rejection region, significance level, power of a test, p-value;
- compare means and proportions of two independent or paired samples using interval estimation and/or hypothesis testing;
- understand how to determine sample size in comparative experiments;
- know inference concerning the variances of two normal populations;

- compare means of more than two independent samples using analysis of variance;
- carry out the sign test, the signed-ranks test and the Mann-Whitney U test, with due regard to the assumptions underlying these procedures;
- interpret the results of statistical analyses correctly and in non-technical language.

Course Outline

1. Introduction to Statistical Inference (5 lecture hours)

1.1 Basic concepts: population, sample, parameter, statistic
1.2 Review of descriptive statistics
1.3 Review of probability concepts and distributions
1.4 Sampling distribution of a statistic
1.5 Central limit theorem
1.6 Estimation
  1.6.1 Motivating examples
  1.6.2 Point estimation
  1.6.3 Interval estimation
1.7 Hypothesis Testing
  1.7.1 Motivating examples
  1.7.2 Important concepts in testing a statistical hypothesis: statistical hypothesis, null and alternative hypothesis, test of hypothesis, test statistic, rejection region, type I and type II errors, probabilities of type I and type II errors, problem of controlling these probabilities
  1.7.3 Steps in testing a hypothesis

2. Inference about One-Sample (8 lecture hours)

2.1 Inference about Single Mean
  2.1.1 Sampling distribution of the sample mean
  2.1.2 Point and interval estimation of the population mean
  2.1.3 Testing hypothesis about the population mean
2.2 Inference about Single Proportion
  2.2.1 Sampling distribution of the sample proportion
  2.2.2 Point and interval estimation of the population proportion
  2.2.3 Testing hypothesis about the population proportion

3. Inference about Two Means (6 lecture hours)

3.1 Sampling distribution of the difference between two means
3.2 Estimation of the difference between two population means
3.3 Testing hypothesis about the difference between two population means
3.4 Paired Sample Comparison of means

4. Inference about Two Proportions (6 lecture hours)

4.1 Sampling distribution of the difference between two proportions (independent samples)
4.2 Estimation of the difference between two population proportions

4.3 Test about the difference between two proportions
4.4 Paired sample comparison of proportions

5. Sample Size Determination (3 lecture hours)

5.1 One-sample case
5.2 Comparative experiments
5.2.1 Comparing two means from independent samples
5.2.2 Comparing two proportions from independent samples
5.2.3 Comparing two means from paired samples

6. Analysis of Variance (5 lecture hours)

6.1 Introduction
6.2 One-way ANOVA for comparing more than two means
6.3 Fisher's least significant difference

7. Inference on Standard Deviation (4 lecture hours)

7.1 Estimation of standard deviation
7.2 Tests concerning standard deviation
7.3 Tests concerning the ratio of two variances from normal populations

8. Chi-Square Tests (3 lecture hours)

8.1 Introduction
8.2 Test of association

9. Inference using Non-Parametric Methods (8 lecture hours)

9.1 Introduction
9.2 Testing hypothesis about median
9.3 Sign-test
9.4 Wilcoxon signed rank test
9.5 Mann–Whitney U test
9.6 Runs test of randomness

Textbook

Ott, R.L. and Longnecker, M.T. (2008). An Introduction to Statistical Methods and Data Analysis. Duxbury Press.

References

1. Bluman, A.G. (1995). Elementary Statistics: A Step by Step Approach (2nd Edition). Wm. C. Communications, Inc.
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7. Gupta, C.B. and Gupta, V. (2004). An Introduction to Statistical Methods. Vikas Publishing House Pvt. Ltd., India.
8. Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods (8th Edition). Iowa State University Press.
9. Ross, S. M. (2005). Introductory Statistics (2nd Edition). Elsevier Academic Press.
10. Woodbury, G. (2001). Introduction to Statistics. Duxbury press.

Teaching and learning methods

Lectures, tutorials and assignments.

Mode of Assessment

Two or more tests and assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Introduction to Probability Theory**
Course code: **Stat 275**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week, Tutorial 2 hours per week**
Pre-requisite:

Course description
Elementary probability; Random variables; Probability distributions, Cumulative distribution function; Common discrete probability distributions: Binomial, Poisson, Geometric and Hypergeometric; Common continuous distributions: Uniform, Normal, exponential, t, chi-square, and F; Functions of random variables and their distributions, Expectation, Covariance and Correlation.

Objectives
- to introduce students to the fundamental concepts in probability theory;
- to introduce the basic principles and methods of quantification of uncertainty;
- to introduce the basics of random variables, common probability distributions and expectation;
- to introduce two dimensional random variables their probability distributions including marginal and conditional distributions and independence;
- to introduce one and two dimensional functions and computing their probability distribution, expectation, variance and correlation;
- to demonstrate the importance and usefulness of probability in real applications;
- to build up interest in probability and hence encourage students to study more advanced courses.

Learning outcomes
At the end of the course students are expected to:
- equip themselves with basic concepts of probability and a good appreciation of the laws of probability;
- know what is meant by a random variable, probability distribution, cumulative distribution function, probability density function, expectation, variance and correlation;
- use standard statistical tables for the normal, t, chi-square and F distributions;
- understand conditional probability and independence;
- define joint, marginal and conditional distribution and independent random variables;
- be familiar with functions of random variables and derive their probability distributions
- compute expectation, variance and correlation of random variables;
- be familiar with standard discrete and continuous probability distributions and their applications.

Course Outline

1. **Introduction (6 lecture hours)**
   - 1.1 Deterministic and non-deterministic models
   - 1.2 Random experiments, sample space and events
   - 1.3 Review of set theory: sets, union, intersection, complementation, De Morgan's rules
   - 1.4 Finite sample spaces
   - 1.5 Equally likely outcomes
   - 1.6 Counting techniques
   - 1.7 Definitions of probability
   - 1.8 Axioms of probability
   - 1.9 Derived theorems of probability
2. **Conditional Probability and Independence (4 lecture hours)**
   - 2.1. Conditional Probability
   - 2.2 Multiplication rule
   - 2.2 Partition Theorem, Bayes' Theorem and Applications
   - 2.3 Independent Events
3. **One-dimensional Random Variables (4 lecture hours)**
   - 3.1 Random variable: definition and distribution function
   - 3.2 Discrete random variables
   - 3.3 Continuous random variables
   - 3.4 Cumulative distribution function and its properties
4. **Functions of Random Variables (6 lecture hours)**
   - 4.1. Equivalent events
   - 4.2. Functions of discrete random variables and their distributions
   - 4.3. Functions of continuous random variables and their distributions
5. **Expectation (7 lecture hours)**
   - 5.1 Expectation of a random variable
   - 5.2 Expectation of a function of a random variable
   - 5.3 Properties of expectation
   - 5.4 Variance of a random variable and its Properties
   - 5.5 Chebyshev's Inequality
   - 5.6 Covariance and Correlation Coefficient
   - 5.7 Conditional Expectation
6. **Common Discrete Distributions and their Properties (10 lecture hours)**
   - 6.1 Binomial distribution
   - 6.2 Poisson distribution
   - 6.3 Hypergeometric distribution
   - 6.4 Geometric distribution
7. **Common Continuous Distributions and their Properties (11 lecture hours)**
   - 7.1 Uniform distribution
   - 7.2 Normal distribution
   - 7.3 Exponential distribution
   - 7.4 Chi - square distribution

7.5 t distribution
7.6 F distribution

Textbooks

Ross S. (2006). A First Course in Probability (7th Edition). Prentice-Hall, Upper Saddle Rivel, New Jersey.

References

1. Cheaffer, R.L. and McClave, J.T (1994). Probability and Statistics for Engineers (4nd Edition). Duxbury Press.
2. Lipschutz, S. and Schiller, J. (1998). Introduction to Probability and Statistics. Schaum's Outline Series, Mc Graw-Hill.
3. Mendenhall, W., Beaver, R.J. and Bearer, B.M. (2008). Introduction to Probability and Statistics (13th Edition). Duxbury Press.
4. Mendenhall, W., Beaver, R.J. and Bearer, B.M. (2005). Student Solutions Manual for Introduction to Probability and Statistics (12th Edition). Duxbury Press.
5. Walpole, R. E., Myers, S.L. and Ye, K. (2006). Probability and Statistics for Engineers and Scientists (6th Edition). Prentice Hall.
6. Roussas, G. G. (2006). Introduction to Probability. Academic Press.
7. Bertsekas, D. P. and Tsitsiklis, J. N. (2008). Introduction to Probability (2nd Edition). Athena Scientific.
8. Suhov, Y. and Kelbert, M. (2005). Probability and Statistics by Examples. Cambridge University Press.

Teaching and learning methods

Lectures, tutorials and assignments.

Mode of Assessment

Two or more tests and assignments	20%
Mid-Semester Examination	30%
Final Examination	50%
Total	100%

Course title: **Statistical Computing I**
Course code: **Stat 373**
Credit hours: **3**
Contact hours: **Lecture 2 hours per week, Comp Lab 3 hours per week**
Pre-requisite:

Course description
Introduction to statistical computing; Basics of statistical computations in MINITAB and SPSS Software; Statistical data analysis and interpretation: descriptive and inferential analysis and linear regression; Writing and reporting results of analyses.

Objectives
- to expose students to windows-based statistical software for computations;
- to equip students with skills of data entry, analysis and interpretation of results;
- to enhance the students' ability of writing and reporting statistical results.

Learning outcomes
At the end of the course students are expected to:
1. demonstrate the use of MINITAB and SPSS software for statistical analysis;
2. enter and analyze data;
3. interpret the results of data analysis;
4. produce and report statistical results in writing and orally.

Course Outline

1. **Introduction to MINITAB (6 lecture hours)**
   1.1 How to start and exit MINITAB
   1.2 MINITAB windows: Worksheet, Session, Project
   1.3 The spreadsheet window: rows and columns,
   1.4 The menus and their use
   1.5 Type data
   1.6 Entering and saving data
   1.7 Importing and exporting data
2. **Descriptive Statistics using MINITAB (3 lecture hours)**
   2.1 Illustrations using tables and graphs
   2.2 Summary statistics
3. **Customizing Minitab Outputs and Reporting (3 lecture hours)**
   3.1 Editing Minitab outputs
   3.2 Report writing of the analysis results
4. **Introduction to SPSS (6 lecture hours)**
   4.1 How to start and exit SPSS
   4.2 SPSS windows
   4.3 The menus and their use
   4.4 Entering and saving data in SPSS
   4.5 Importing and exporting data

5. **Descriptive Statistics using MINITAB (3 lecture hours)**
   5.1 Illustrations using tables and graphs
   5.2 Summary statistics
6. **Customizing SPSS Outputs and Reporting (3 lecture hours)**
   6.1 Editing SPSS outputs
   6.2 Report writing of the analysis results

7. **Statistical Analysis using MINITAB and SPSS (8 lecture hours)**
   7.1 Inferential statistics
      7.1.1. Point and interval estimations
      7.1.2. Testing of hypothesis about one population mean and proportion
      7.1.3. Comparison of two population means and proportions
      7.1.4. Comparison of more than two population means (ANOVA)
      7.1.5. Tests of goodness of fit and of independence
      7.1.6. Non-parametric statistical tests
   7.2 Regression and Correlation
      7.2.1. Fitting simple linear regression
      7.2.2. Correlation and rank correlation
      7.2.3. Multiple regression
      7.2.4. Regression diagnostics

Textbooks

1. Fesq, J. (2004). Minitab Manual for Introductory Statistics.
2. Peck, R. (2005). SPSS Manual for Introductory Statistics.
3. Givens, G.H. and Hoeting, J.A. (2005). Computational Statistics.

References

1. MINITAB manuals.
2. SPSS Manual: SPSS Base Version User's Guide, SPSS Inc.
3. Freund, J. E. and Walpole, R. E. (1980). Mathematical Statistics.
4. Mann, P. S. (2006). Introductory Statistics.
5. Krzanowski, W. J. (1998). An Introduction to Statistical Modelling.
6. Puri, B. K. (1996). Statistics in Practice: An Illustrated Guide to SPSS. Oxford University Press, Inc.
7. Gupta, C.B. and Gupta, V. (2004). An Introduction to Statistical Methods. Vikas Publishing House, Pvt. Ltd, India.

Teaching and Learning Methods

Lecture with intensive computer lab practice.

Mode of Assessment and Evaluation

Practical tests (at least two)	30%
Assignments and computer lab reports	20%
Final Exam (practical and written)	50%
Total	100%

Course title: **Sampling Theory**
Course code: **Stat 372**
Credit hours: **4**
Contact hours: **Lecture 4 hours per week, Tutorial 1 hours per week**
Pre-requisite: **Stat 272**

Course description
Introduction; Simple random sampling; Confidence intervals; Sample size; Estimating proportions, ratios, and subpopulation means; Unequal probability sampling; Auxiliary data and ratio estimation; Regression estimation; Stratified sampling; Cluster and systematic sampling; Multistage designs; Double sampling; Line transects.

Objective
The objective of the course is to present basic concepts and designs used in sample survey.

Learning outcomes
Upon successful completion of this course students are expected to:

- Understand the basic concepts in sampling theory,
- Compute sample size required for estimation of specific parameter,
- Derive estimators for common parameters,
- Estimate common parameters of interest form different sample designs,
- Estimate variance of different parameter estimators from various sample designs,
- Distinguish the application of several sampling designs,
- Identify and design appropriate sampling method for specific data collection problem,
- Use auxiliary information in both sampling design and estimation of parameters, and
- Use Ratio and Regression estimators in sample survey.

Course Outline

1. **Introduction (2 Lecture hours)**
   1.1 Basic ideas of sampling and estimation
   1.2 Sampling units
   1.3 Sampling and non sampling errors
2. **Simple random sampling (8 Lecture hours)**
   2.1 Selecting a simple random sampling
   2.2 Estimating the population mean with derivation
   2.3 Estimating the population total with derivation
   2.4 Some underling ideas
   2.5 Random sampling with replacement
3. **Confidence Intervals (2 Lecture hours)**
   3.1 Confidence interval for the population mean or total
   3.2 The finite population central theorem
4. **Sample Size (2 Lecture hours)**
   4.1 Sample size for estimating a population mean

4.2 Sample size for estimating a population total
4.3 Sample size for relative precision

5. Estimating Proportions, Ratios and Subpopulation Means (8 Lecture hours)

5.1 Estimating a population proportion
5.2 Confidence interval for a population proportion
5.3 Sample size for estimating a proportion
5.4 Sample size for estimating several proportions simultaneously
5.5 Estimating a ratio
5.6 Estimating a mean, a total, or proportion of a subpopulation

6. Unequal Probability Sampling (6 Lecture hours)

6.1 Sampling with replacement: The Hansen-Hurwaz estimator and derivation
6.2 The Horvitz-Thompson estimator and derivation

7. Auxiliary Data and Ratio Estimation (6 Lecture hours)

7.1 The ratio estimator
7.2 A small population illustrating bias
7.3 Derivations and approximations for the ratio estimator
7.4 The finite population central limit theorem for the ratio estimator
7.5 Ratio estimation with unequal probability designs
7.6 Models in ratio estimation
7.7 Design implications of ratio models

8. Regression Estimation (6 Lecture hours)

8.1 The line regression estimation
8.2 Regression estimation with unequal probability designs
8.3 A regression model
8.4 Multiple regression models
8.5 Design implication of regression models

9. Stratified Sampling (8 Lecture hours)

9.1 Estimating the population total with derivation
9.2 Estimating the population mean with derivation
9.3 Confidence intervals
9.4 The stratification principle
9.5 Allocation in stratified random sampling
9.6 Post stratification

10. Cluster and Systematic Sampling (8 Lecture hours)

10.1 Primary units selected by simple random sampling
10.2 Primary units selected with probabilities proportional to size
10.3 Basic principle
10.4 Single systematic sample
10.5 Variance and cost in cluster and systematic sampling

11. Multistage Designs (8 Lecture hours)

11.1 Simple random sampling at each stage
11.2 Primary units selected with probability proportional to size
11.3 Multistage design with replacement
11.4 Cost and sample sizes
11.5 Derivation for Multistage designs

Textbook

1. Thompson, S.K. (2002). Sampling , 2nd Ed, Wiley, New York.
2. Cochran, W. G. (1977). Sampling Techniques, 3rd , Ed, John Wiley& Sons, Inc., New York.

References

1. Des Raj and Chandak (1998). Sampling Theory.
2. Mukhopadhyay, P. (1998). Theory and Methods of Survey Sampling, Prentice-Hall, India.
3. Sukhatme, P. V. and Sukhatme, B.V. (1992). Sampling Theory of Surveys with Applications. lowa State University Press & IARS.
4. Henry, Gary T. (1990). Practical Sampling: Applied Social Research Methods Series. Sage: Newbury Park, CA.
5. Kish, L. (1965). Survey Sampling. Wiley, New York.
6. Sarndal, C.E. and Swensson, B. and Wretman, J.H. (1992). Model Assisted Survey Sampling. Springer-verlag, New York.
7. Hansen, M. H., Hurwitz, W. N. and Madow, W. G. (1953). Sample Survey Methods and Theory. Vols. I-II, New York: John Wiley& Sons.
8. Kumar, R. S. (1996). Practical Sampling Technique (2nd Edition). Marcel Deker: New York.
9. Vogel, F. A. (1986). Sample Design and Estimation for Agricultural Sample Surveys. Statistical Reporting Service, NASS/USDA, Washington.
10. Singh and Chaudhary (1986). Theory and Analysis of Sample Survey Designs.

Teaching methods

Lecture, Reading Assignment, Exercises, Tutorial and Simple case study.

Mode of Assessment

Two or more tests and Assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Statistical Computing II**
Course code: **Stat 374**
Credit hours: **3**
Contact hours: **Lecture 2 hours per week, Computer practice 3 hours per week**
Pre-requisite: **Stat 373**

Course description
Introduction to R; Simple manipulations; Objects; Data storage and Management; Probability distributions; Grouping, loops and conditional execution; Writing functions; Statistical models in R; Graphical procedures; Monte Carlo methods in inference; Numerical methods in R; Overview of the SAS language and simple procedures for graphing and data analysis.

Objectives
- To introduce the R language to students as environment to understand and explore statistics;
- To introduce SAS for statistical data analysis.

Learning outcomes
At the end of this course, students are expected to:
- load, manipulate, and use data in R,
- run basic models,
- perform matrix algebra in R,
- write simple functions and programs in R,
- program maximum likelihood estimators,
- carryout simulation for estimation and hypothesis test,
- install packages and use them for upper-level methods,
- draw graphs using the base and lattice graphics packages,
- use the R software for statistical computation and analysis,
- use resources about R to look-up more information about it.
- use SAS to carry out simple graphs and data analysis.

Course Outline

1. Introduction to R (10 Lecture hours)
1.1 The R environment
1.2 Getting started with R and the online help system
1.3 Commands and execution
1.4 Simple manipulation
1.4.1. Vectors; Generating sequences; Objects
1.4.2. Data storage and Management
1.4.3. Arrays, Matrices, Lists, Data frames; Reading data

2. **Probability and Sampling Distributions (6 Lecture hours)**
   2.1 R as a set of statistical tables
   2.2 Examining the distribution of a set of data
   2.3 Simulating the Sample Distribution of the Mean
   2.4 One and two sample tests
3. **Writing Functions (8 Lecture hours)**
   3.1 Grouping, loops and conditional execution
   3.2 Writing functions
   3.3 Simple examples
   3.4 Binary operators
   3.5 More advanced examples
   3.6 Classes, generic functions and object orientation
4. **Graphical procedures (4 Lecture hours)**
   4.1 Plotting commands
   4.2 Graphics Parameters
5. **Monte Carlo methods in inference (4 Lecture hours)**
   5.1 Monte Carlo methods for estimation
   5.2 Monte Carlo methods for hypothesis test
6. **Numerical Methods in R (4 Lecture hours)**
   6.1 Optimization
   6.2 Maximum likelihood estimation
7. **Statistical Models in R (4 Lecture hours)**
   7.1 Regression
   7.2 ANOVA models
   7.3 Time Series models
   7.4 Others
8. **Introduction to SAS (8 Lecture hours)**
   8.1 SAS Language
   8.2 Overview of SAS
      8.2.1. Accessing and Exiting SAS; Getting Help; Data Step; SAS Constants
      8.2.2. Variables, and Expressions; Input and Output
      8.2.3. SAS Procedures for Data Analysis
             PROC FREQ, PROCMEANS, PROC CORR, PROC REG
      8.2.4. SAS Procedures for Graphing
             PROC PLOT, PROCGPLOT, PROC CHART, PROCGCHART

Textbooks

1. Venables W. N., Smith D. M. and the R Development Core Team (2009). An Introduction to R, Version 2.9.1 (2009-06-26). (Available with software under the menu help- manuals -in pdf)
2. Venables W.N. and Ripley B. D (2002). Modern Applied Statistics (4th Edition). Springer, New york.
3. Base SAS (2006). Base SAS 9.1.3 Procedures Guide, Second Edition, Volumes 1-4, SAS Publishing.

References

1. Dalgaard, P. (2002). Introductory Statistics with R. Springer-Verlag, New York
2. Rizzo M. L (2008). Statistical Computing with R. Chapman & Hall/CRC.
3. Maindonald, J. and Braum, J. (2003). Data Analysis and Graphics using R: an Example-based Approach. Cambridge University Press.
4. Fox, J. (2002). An R and S-PLUS Companion to Applied Regression. Sage Books.
5. Spector, P. (1994). An Introduction to S and S-PLUS. Duxbury Press.
6. Becker R. A., Chambers J. M. and. Wilks A. R (1988). The New S Language. Chapman& Hall, New York.
7. Chambers J. M. and Hastie T. J. eds. (1992). Statistical Models in S. Chapman & Hall, New York.
8. Chambers J. M. (1998). Programming with Data. A Guide to the S Language. Springer-Verlag.
9. R Project, "What is R?" (http://www.r-project.org/about.html).
10. Horton N. J., Brown E. R., and Qian L. (2004). Use of R as a Toolbox for Mathematical Statistics Exploration. The American Statistician, Vol. 58, No. 4
11. Base SAS 9.1.3 Procedures Guide (2nd Edition). Volumes 1-4, SAS Publishing.

Teaching methods

Lecture; Reading Assignment; Practice of simulation and analysis using R and SAS software.

Mode of Assessment

At least two tests and assignments	20%
Mid-Semester exam	30%
Final Exam	50%
Total	100%

Course title: **Design and Analysis of Experiments**
Course code: **Stat 376**
Credit hours: **4**
Contact hours: **Lecture 4 hours per week, Tutorial and computer practice 2 hours per week**
Pre-requisite: **Stat 272**

Course description
Introduction; Simple comparative experiments; Single factor ANOVA; More about single factor experiment; Randomized blocks, Latin squares, and Related designs; Factorial designs; The 2^K factorial design; More on 2^K factorial designs: Blocking, confounding and fractional designs; Nested and Split plot designs; Analysis of covariance.

Objective
The objective of this course is to present the theoretical foundation of several experimental designs along with respective statistical analysis as applied in several scientific studies.

Learning outcomes
At the end of the course students are expected to:

- define basic concepts of experimental design including experimental units, randomization, replication, control, factor, treatments etc.,
- identify the principles for the application of different experimental designs including Complete Randomization, Randomized Block, Latin Square, Split Plot, Nested, Factorial, Fractional Factorial designs etc.,
- define the statistical models and hypothesis tests for different experimental designs,
- derive test procedures and computational formulas for hypothesis tests in experimental studies,
- perform statistical analysis (including multiple comparison test) and construct ANOVA/ ANCOVA tables for different experimental designs,
- apply blocking and confounding design techniques in the 2^K factorial design,
- use appropriate statistical software for the statistical analysis,

Course Outline

1. **Introduction (4 Lecture hours)**
   1.1 Strategy of experimentation
   1.2 Some typical Applications of Experimental Designs (Motivating Examples from agriculture and others)
   1.3 Basic principles
   1.4 Guidelines for Designing Experiments
   1.5 Historical Perspective
2. **Simple Comparative Experiment (4 Lecture hours)**
   2.1 Basic statistical concepts
   2.2 Sampling and sampling distribution
   2.3 Inference about the difference in means: Randomized design and Paired

2.4 Comparison design
2.5 Inferences about the variances of normal distribution

3. **Completely randomized design: Single factor Analysis of Variance (ANOVA) (12 Lecture hours)**
   3.1 Examples
   3.2 The analysis of variance
   3.3 The analysis of the model
      3.3.1. Decomposition of the total sum of squares
      3.3.2. Statistical analysis
      3.3.3. Estimation of the model parameters
      3.3.4. Unbalanced data
   3.4 Model adequacy checking
   3.5 Practical interpretation of results
      3.5.1. Comparison among treatment means
      3.5.2. Graphical comparison of means
      3.5.3. Contrasts
      3.5.4. Orthogonal contrasts
      3.5.5. Comparing pairs of treatment means
      3.5.6. Comparing treatment means with control
   3.6 More about single factor experiment
      3.6.1. Choice of sample size: Operating characteristic curves
      3.6.2. Fitting response curves
      3.6.3. Least square estimation of the model parameters
      3.6.4. Repeated measures
4. **Randomized Blocks (4 Lecture hours)**
   4.1 Why Blocking?
   4.2 Statistical analysis (Model, Test procedures, Computational formulas, ANOVA table, and multiple comparisons)
5. **Latin squares, and Related Designs (4 Lecture hours)**
   5.1 The Latin square design (design, statistical analysis)
   5.2 The Graeco-Latin square design(design, statistical analysis)
   5.3 Balanced incomplete block design (design, statistical analysis)
6. **Factorial Designs (20 Lecture hours)**
   6.1 Basic definitions and principles
   6.2 The advantage of factorials
   6.3 The two factor factorial design (with and without interaction)
      6.3.1. Two factorial design without interaction
      6.3.2. Two factorial design with interaction
   6.4 The three factor factorial design
   6.5 Blocking in a factorial design
   6.6 Unbalanced data in a factorial design
   6.7 The 2^K factorial design
      6.7.1. Introduction
      6.7.2. The 2^2 design
      6.7.3. The 2^3 design

6.7.4. Blocking and confounding in 2^2 and 2^3 designs

7. Nested and Split Plot Designs (6 Lecture hours)

7.1 The two-stage nested designs
7.2 The split plot design
7.3 The split-split plot design

8. Analysis of Covariance (ANCOVA) (6 Lecture hours)

8.1 Introduction
8.2 ANCOVA for completely randomized design
8.3 ANCOVA for blocked randomized design

9. Class Project (4 presentation hours)

Students carryout simple project that involves designing, conducting, and analysis of an experiment. This could be a team work and must be presented in both orally and in written form.

Teaching methods

Lecture; Reading Assignment, Exercises; Tutorial; Computer lab work (Statistical analysis using relevant statistical software such as R); Simple case study.

Mode of Assessment

At least two tests and class project	20%
Mid-Semester exam	30%
Final Exam	50%
Total	100%

Textbook

Montogomery, D.C. (1997). Design and Analysis of Experiments (4th Edition). John Wiley & Sons Inc.

References

1. Kuehl R. O. (2000). Design of Experiments: Statistical Principles of Research Design and Analysis, 2nd Ed. Duxbury press.
2. Winner B. J (1971). Statistical Principles in Experimental Design (2nd Edition).
3. Hicks C. R. and Turner K. V. (1999). Fundamental Concepts in the Design of Experiment (5th Edition).
4. Anderson, V. L., and McLean, R. A. (1974). Design of Experiments. Marcel Dekker, New York.
5. Gill, J. L. (1978). Design and Analysis of Experiments in the Animal and Medical Sciences. Vol 1. Iowa State University Press, Iowa.
6. Lindeman, H. R. (1974). Analysis of Variance in Complex Experimental Designs. W. H. Freeman, San Francisco.
7. Ogawa, J. (1974). Statistical Theory in the Analysis of Experimental Design. Marcel Dekker, New York.
8. Raktoe, B. L., Hedayat A. and Federer W. T. (1981). Factorial Designs. Wiley, New York.

Course title: **Demography**
Course code: **Stat 377**
Credit hours: **3**
Contact hours: **Lecture 3 hrs and Tutorial 1 hr per week**
Pre-requisite:

Course description
Introduction to population statistics; Growth and age structure of human populations; Regional and spatial distribution of a population; Analysis of Mortality: Crude and adjusted death rate, Age specific mortality rate, Infant and child mortality and maternal death rate; Analysis of fertility: marriage, fertility, crude fertility rate, age specific fertility rate, gross and net reproduction rate; other measures of fertility; Immigration and Emigration and their measurement; Life table construction; Indirect techniques; Population projection.

Objectives
- to introduce students to demography and population studies;
- to introduce to demographic data and the techniques used in the collection of demographic data;

Learning outcomes
Upon successful completion of this course students are expected to:
- be familiar with the principal sources of demographic data, together with their strengths and weaknesses;
- understand the demographic significance of age structure, together with the implications of variations in age structure;
- be able to specify and calculate the principal demographic measures, and understand how they are interpreted;
- understand the rationale for and be able to apply methods of standardization;
- be able to construct and interpret simple life tables;
- understand how national and local population estimates are made;
- to identify demographic or population variables and their consequences;

Course Outline

1. **Introduction to Population Statistics (6 lecture hours)**
   1.1 Some demographic concepts
   1.2 Development of demographic studies
   1.3 Types and sources of population data
   1.4 Data collection methods and mechanisms: Population Census, Vital Statistics, Registration System and Sample Surveys
   1.5 Data collection instruments
   1.6 Demographic data items
   1.7 Basic demographic measures
2. **Growth and Age Structure of Human Population (8 lecture hours)**

2.1 Growth and sex Composition of Population
2.2 Sex Ratio
2.3 Age Composition
2.4 Whipple's Index
2.5 Myers's Blended Index
2.6 Age Ratio Analysis
2.7 United Nations Age-Sex Accuracy Index
2.8 Population pyramids
2.9 Age Dependency Ratio
2.10 Regional and Spatial Distribution

3. **Mortality and Life Table (8 lecture hours)**
   3.1 Concepts and measurement of Death Statistics
   3.2 Basic Mortality Measures
   3.3 Crude Death Rate
   3.4 Age - Specific Mortality rates
   3.5 Standardization Methods
   3.6 Graphical Presentation of Age-Specific Death Rates
   3.7 Infant and child Mortality Rates
   3.8 Maternal Death Rates
   3.9 Construction of Life Tables and Calculation of Life Table Functions.
4. **Fertility (8 lecture hours)**
   4.1 Concept of Fertility
   4.2 Fertility Statistics
   4.3 Child-Woman Ratio
   4.4 Crude Birth Rate
   4.5 General Fertility Rate
   4.6 Age-Specific Fertility Fates
   4.7 Total Fertility rate
   4.8 General Marital Fertility rate
   4.9 Age-Specific Marital Fertility Rate
   4.10 Marital Fertility Rate
   4.11 Gross Reproduction Rate and Net Reproduction Rate.
5. **Migration (6 lecture hours)**
   5.1 Concepts of Migration, International Migration and Internal Migration
   5.2 Sources of Internal Migration Data
   5.3 Direct and Indirect Migration Data Collection Methods
   5.4 Measurement of Internal Migration
   5.5 In-Migration, Out-Migration and Net Migration Rates
   5.6 Concepts of Immigration, Emigration and their Measurement.
6. **Population Dynamics (6 lecture hours)**
   6.1 Measurement of Population Change
   6.2 Rate of Population Growth: Exponential and Logistic Models
   6.3 Effects of Fertility, Mortality and Migration on Population Sizes and Structure
   6.4 Concepts of Stable and stationary population
7. **Population Estimates and Population Projection (6 lecture hours)**

7.1 Types of Population estimates
7.2 Nature and types of population projection
7.3 Cohort component method of projection with base population specification
7.4 Projection of components
7.5 Uses of population projection.

Textbook

Shryock, H.S, and Siegel, J.S. (1976): The Methods and Materials of Demography. Studies in Population, Academic Press, California, USA.

References

1. Brass, W. (1975). Methods for Estimating Fertility and Mortality from Limited and Defective Data. Laboratories for Population Statistics, Carolina Population Centre. Chapel Hill, North Carolina.
2. Brass, W., Coale, A.J., Demeny, P., Heisel, D.F., Lorimer, F., Romanjuk, A. and Van de Walle, E. (1968). The Demography of Tropical Africa. Princeton University Press, Princeton, New Jersey.
3. Hinde, A. (1998). Demographic Methods. A Hodder Arnold Publication.
4. Newell, C. (1988). Methods and Models in Demography. Belhaven Press, London, UK.
5. Pathak, K.B. and Ram, F. (1992). Techniques of Demographic Analysis. Himalaya Publishing House, Mumbai.
6. Rives, N.W., and Serow, W.J. (1984). Introduction to Applied Demography: Data Sources and Estimation Techniques. Quantitative Applications in the Social Sciences, Sage Publications, Inc.
7. Rowland, D.T. (2003). Demographic Methods and Concepts. Oxford University Press, USA.
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9. Spiegelman, M. (1976). Introduction to Demography. Harv and University Press, USA.
10. United Nations (1983). Indirect Techniques for Demographic Estimation. Population studies, No.81, Department of International Economic and Social, United Nations, New York.
11. Yaokey, D., Anderton. D.C. and Lundquist, J.H. (2007). Demography: The study of Human Population. Waveland Press.

Course title: **Time Series Analysis**
Course code: **Stat 378**
Credit hours: **4**
Contact hours: **Lecture 4 hrs per week, Tutorial and computer lab 2 hrs per week**
Pre-requisite: **Stat 272**

Course description
Definition and concepts; Objectives; Time series data, Components of time series analysis; Additive and multiplicative models; Tests of randomness; Constant mean model, estimation methods; Linear trend estimation using moving average, Least squares, Exponential smoothing methods; Seasonal variation, estimation using simple average, moving average, dummy variable, exponential smoothing; Cyclical variation; Introduction to Box-Jenkins models: Stationary, Autoregressive (AR), Moving Average (MA), Autoregressive Moving Average (ARMA), ARIMA models; Forecasting Methods.

Objectives
The objectives of the course are:

- to introduce students to the theory and methods of time series analysis;
- to equip students with skills of applying various time series models;
- to enable students to use standard software for related computations;

Learning outcomes
At the end of the course students are expected to

- demonstrate basic time series concepts, theories and methods;
- distinguish among different components of time series and type of models to apply;
- model time series data and select model ;
- use statistical software for analyzing time series data;
- make forecasting and interpret the results.

Course Outline

1. **Introduction (4 lecture hours)**
   1.1 Definition and Terminology
   1.2 Objectives of Time Series Analysis
   1.3 Significance of Time Series Analysis
   1.4 Components of Time Series
   1.5 Models of Time Series
   1.6 Editing of Time Series Data
2. **Tests of Randomness (3 lecture hours)**
   2.1 Turning point Test
   2.2 Difference sign test
   2.3 Phase length Test
   2.4 Rank Test
3. **Estimation (12 lecture hours)**

3.1 Constant mean model and its estimation
Free-hand Method, Method of semi-averages, Least squares method, Moving average, Exponential smoothing method
3.2 Linear Trend and its estimation
Least squares method, Moving average method, Exponential smoothing method
3.3 Non-linear trend and its estimation
Polynomial trend

4. Estimation of Seasonal Component (6 lecture hours)
4.1 Simple Average Method
4.2 Link Relative Method
4.3 Ratio-to-Moving Average Method
4.4 Ratio-to-Trend Method
4.5 Use of Dummy variables
4.6 Smoothing models for Seasonal Data
4.7 Uses and limitations of seasonal Indexes
4.8 Deseasonalization of Data

5. Estimation of Cyclical and Irregular Components (3 lecture hours)
5.1 Cyclical component and its estimation
5.2 Irregular component and its estimation

6. Introduction to Box-Jenkins Models (12 lecture hours)
6.1 Introduction
6.2 The concept of Stationarity
6.3 ARIMA models
6.4 Methodological tools for model identification
Autocorrelation function, Partial autocorrelation function
6.5 Stages of Box-Jenkins methodology

7. Model Identification and Estimation (18 lecture hours)
7.1 Autoregressive models: AR(1), AR(2) and AR(p)
7.2 Moving average models: MA(1), MA(2) and MA(q)
7.3 Autoregressive moving average models: ARMA(1,1), ARMA(p,q)
7.4 Autoregressive integrated moving average models: ARIMA(p,d,q), ARIMA(1,1,1)
7.5 Least squares methods
7.6 Diagnostic checking

8. Forecasting (6 lecture hours)
8.1 Need and use of forecasting
8.2 Some forecasting methods
Averaging methods, Exponential smoothing methods, Box-Jenkins methods, Decomposition methods
8.3 Accuracy of forecasting methods

Textbook

Chatfield, C. (2003). The Analysis of Time Series: An Introduction.

References

1. Shumway, R.H. and Stoffer, D.S. (2006). Time Series Analysis and Its Applications: With R Examples.
2. Brockwell, P.J. and Davis, R.A. (2009). Time Series: Theory and Methods.
3. Montgomery, D.C. and Johnson, L.A. and Gardiner, J.S. (1990). Forecasting and Time Series Analysis.
4. Cryer, J.D and Chan, K.S. (2009). Time Series Analysis: With Applications in R.
5. Box, G.E.P, Jenkins, G.M., and Reinsel, G.C. (2008). Time Series Analysis: Forecasting and Control.
6. Brillinger, D.R. (2001). Time Series: Data Analysis and Theory.
7. Vandaele, W. (1983). Applied Time Series and Box-Jenkins Models.
8. Kendall, M. (1990). Introduction to Time Series Analysis.
9. Fuller, W.A. (1976). Introduction to Statistical Time Series.
10. Janacek, G. (2001). Practical Time Series.

Teaching and Learning Methods

Lecture, self reading, demonstration, exercises, practice using computer software.

Mode of Assessment and Evaluation

At least two tests and Assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course Title: **Regression Analysis**
Course Code: **Stat 379**
Credit Hours: **3**
Contact hours: **Lecture 3 hours, Tutorial and Computer lab 2 hours per week**
Prerequisite: **Stat 272**

Course Description
Simple linear regression: parameter estimation and model fitting; model checking (R-square, residual plot an PP- plot); prediction; inference about parameters; linear correlation and inference about correlation coefficient; The multiple linear regression: model assumptions, model fitting; R-square; partial correlation coefficients; model diagnostics, partitioning sum of squares, ANOVA table construction, test of hypothesis, prediction, dummy variables; effects of departures from model assumptions; forward and backward procedures.

Objectives
- Introduce how to build a linear regression model and show when such a model is appropriate demonstrate the association between a set of explanatory variables and a response variable.
- Expose the statistical theory up on which linear regression is built – assumptions and the like.
- Apply estimation methods; make predictions and inferences; checking for any violations of model assumptions.
- Apply procedures of variable selection to include relevant explanatory variable in the model.

Learning Outcomes
At the end of the course students are expected to:
- have acquired enough theoretical knowledge about linear regression analysis,
- be able to ascertain if the model assumptions are met before applying techniques of estimation and making inferences/predictions based on a given real data set,
- be able to identify important variables (from a larger pool of variables) need to be included in order to make a linear regression model meaningful.

Course Outline

1. **Introduction (2 lecture hours)**
   - 1.1 Regression and model building
   - 1.2 Data collection
   - 1.3 Uses of regression
2. **Simple Linear Regression (6 lecture hours)**
   - 2.1 Simple linear regression model
   - 2.2 Least-Squares Estimation of the model parameters
   - 2.3 Inference about the slope and the intercept and the slope parameters
   - 2.4 Prediction of new observations

2.5 Estimation by maximum likelihood

3. Multiple Linear Regression (8 lecture hours)

3.1 Multiple linear regression models
3.2 Least-Squares Estimation of the model parameters
3.3 Inference in multiple linear regression
3.4 Prediction of new observations

4. Model Adequacy Checking (6 lecture hours)

4.1 Residual analysis
4.2 Detection and treatment of outliers
4.3 Lack of fit of the regression model

5. Transformations and Weighting (9 lecture hours)

5.1 Variance-Stabilizing transformations
5.2 Transformations to linearized the model
5.3 Analytical methods for selecting a transformation
5.4 Generalized and weighted least-squares

6. Diagnostics for Leverage and Influence (8 lecture hours)

6.1 Leverage
6.2 Measures of influence: Cook's D, DFITS and DFBETAS
6.3 Detecting groups of influential observations
6.4 Treatment of influential observation

7. Variable Selection and Model Building (9 lecture hours)

7.1 Introduction: the model building problem
7.2 Model misspecification
7.3 Criteria for evaluating subset regression
7.4 Computational techniques for variable selection: all possible regressions
7.5 Stepwise regression methods

Textbook

Montgomery, D.C., Peck, E.A. and Vining, G.G. (2002). Introduction to Linear Regression Analysis (3rd Edition). John Wiley & Sons, Inc., New York.

References

1. Carroll, R.J. and Ruppert, D. (1988). Transformation and Weighting in Regression. Chapman-hall, London
2. Chatterjee, S. and Price, B. (1977). Regression Analysis by Example. Wiley, New York.
3. Daniel, C. (1976). Applications of Statistics to Industrial Experimentation. Wiley, New York.
4. Draper, N.R. and Smith, H. (1998). Applied Regression Analysis (3rd Edition). John Wiley & Sons, Inc., New York.
5. Mosteller, F. and J.W.Tukey (1977). Data Analysis and Regression: A second Course in Statistics. Addison-Wesley, Reading, Mass.
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8. Ryan, T.P. (1997). Modern Regression Methods. Wiley, New York.
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10. Seber, G.A.F. (1977). Linear Regression Analysis. Wiley, New York
11. Weisberg, S. (1985). Applied Linear Regression (2nd Edition). Wiley, New York.
12. Younger, M.S. (1979). A Handbook of Linear Regression. Duxbury Press. North Scituate, Massachussets.

Teaching and Learning Methods

Lecture, tutorial and computer laboratory practice.

Mode of Assessment

At least two tests and Assignment	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Statistical Theory of Distributions**
Course code: **Stat 471**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week, Tutorial 2 hours per week**
Pre-requisite: **Stat 275**

Course description
Probability concepts, Random Variables, distribution functions and expectation, Moments, Moment Generating Functions, Common univariate distributions – Binomial, Hypergeometric, Poisson, Geometric, Negative Binomial, Uniform, Normal, Exponential, Gamma, Beta, Cauchy. Joint and conditional distributions; Common multivariate distributions – trinomial, multinomial, multivariate normal, bivariate normal; moment generating functions and moments of multivariate distributions; marginal and conditional densities; Distributions of functions of random variables and applications for the continuous and discrete cases; Sampling and sampling distributions; Order Statistics and their distributions; the sample or empirical cumulative distribution function; Limit theorems: convergence, weak law of large numbers and central limit theorem.

Objectives
- to develop a solid foundation in calculus of probabilities and to indicate the relevance and importance in tackling real-life problems;
- to introduce multivariate distributions and the derivation of marginal and conditional distributions;
- to obtain the distribution of functions of random variables using cumulative distribution function technique, moment generating methods and transformation of variables;
- to introduce order statistics and their distributions, empirical distribution, the sampling distribution of the sample mean and the distributions of statistics like z, t, F and chi-square;
- to introduce convergence of random variables, weak law of large numbers and central limit theorem.

Learning outcomes
Upon successful completion of this course students are expected to:
- understand the concept of both univariate and multivariate random variables and their joint, marginal and conditional distributions;
- able to evaluate the distribution of functions of random variables and their expectations;
- know most commonly used probability distribution and their properties and applications;
- understand empirical distribution, sampling distribution of the sample mean and other statistics (normal, t, F and chi-square) including order statistics;
- understand the concept of convergence of random variables, weak law of large numbers and central limit theorem.

Course Outline

1. **Review of Probability Theory (3 lecture hours)**
    - 1.1 Probability concepts
    - 1.2 Distribution Functions
    - 1.3 Expectations
    - 1.4 Moments
    - 1.5 Moment Generating Functions
2. **Common Univariate Distributions (13 lecture hours)**
    - 2.1 Discrete Distributions: Binomial, Negative Binomial, Geometric, Hypergeometric, Poisson and Pascal
    - 2.1 Continuous Distributions: Uniform, Normal, Gamma, Exponential, Weibull, Chi-square, Beta and Cauchy
    - 2.4 Truncated Distributions
3. **Common Multivariate Distributions (13 lecture hours)**
    - 3.1 Multi-dimensional random variables
    - 3.2 Trinomial and Multinomial distributions
    - 3.3 Bi-variate and Multivariate Normal distributions
    - 3.4 Moments and Moment Generating Functions
    - 3.5 Marginal and Conditional Distributions
    - 3.6 Independent random variables
    - 3.7 Distribution Functions of Functions of Random Variables
        - 3.7.1 Cumulative distribution function Technique
        - 3.7.2 Moment Generating Function technique
        - 3.7.3 Transformations

4 **Sampling Distributions (13 lecture hours)**
- 4.1 The normal distribution
- 4.2 The Chi-Square Distribution
- 4.3 The t-Distribution
- 4.4 The F distribution
- 4.5 Order Statistics
    - 4.5.1 Definition of order statistics
    - 4.5.2 Derivation of distribution function and density for the ith order statistics
    - 4.5.3 Derivation of the joint pdf of the ith and jth order statistics
    - 4.5.4 Distributions of the sample range and sample median
- 4.6 The sample cumulative distribution function (empirical distribution)
    - 4.6.1 Definition
    - 4.6.2 Distribution of the empirical distribution

5 **Introduction to Limit Theorems (6 lecture hours)**
- 5.1 Sequence of random variables
- 5.2 Convergence in probability and mean square
- 5.3 Weak law of large numbers
- 5.4 Central limit theorems

Textbook

Mood, A.M, Graybill, F. and Boes, D.C. (1974). Introduction to the Theory of Statistics (3rd Edition). McGraw Hill Series.

References

1. Balakrishnan N. and Nevzorov V.B (2003). A Primer on Statistical Distribution. Wiley-Interscience.
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Teaching and learning methods

Lectures, tutorials and assignments.

Mode of Assessment

Two or more assignments & tests	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Statistical Inference**
Course code: **Stat 472**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week, Tutorial 2 hours per week**
Pre-requisite: **Stat 471**

Course description
Definition, basic concepts and properties of a point estimator; Sufficiency, Completeness, exponential family of distributions; Parametric point estimation, methods of finding point estimates: unbiased estimation, method of moments, maximum likelihood and Bayesian; Parametric interval estimation, Confidence interval, Method of finding interval estimates: pivotal quantity method and large sample asymptotic distributions, some applications; Tests of hypotheses: basic concepts, Most powerful test, Neyman-Pearson lemma, Generalized likelihood ratio test, uniformly most powerful test, monotone likelihood ratio, unbiased test, applications: tests on the mean, the variance, several means, several variances; chi-square tests; relationship between tests and confidence intervals; Sequential test: sequential probability ratio test and some of its properties; Introduction to non-parametric methods: inference concerning the empirical distribution, quantiles and equality of two distributions.

Objectives
- to provide students with the Theory of Statistical Inference: Point and Interval Estimation, Tests of Hypotheses, and Applications.
- to introduce estimation and hypothesis testing methods based on likelihood and other methods
- to introduce students to the principles of efficient estimation and hypothesis testing and acquaint them with best methods of estimation and construction of test procedures

Learning outcomes
On successful completion of this course students are expected to:
- understand the underlying statistical theory of estimation and hypothesis testing;
- determine how good an estimator or test procedure is based on a number of criteria;
- construct estimators and test procedures based both on the maximum likelihood and Bayesian principles.

Course Outline

1. **Parametric Point Estimation (15 lecture hours)**
   - 1.1 Introduction: notion of parameter, parameter space, vector of parameters, problems of estimation
   - 1.2 Definition of point estimator
   - 1.3 Properties of estimators
     - 1.5.1 Unbiasedness
     - 1.5.2 Mean squared error
     - 1.5.3 Efficiency

1.5.4 Consistency

1.6 Sufficiency and completeness

1.6.1 Concept and definition of sufficiency

1.6.2 Factorization theorem

1.6.3 Completeness

1.6.4 Sufficient statistics

1.6.5 Exponential family of distributions

1.7 Methods of Finding Point Estimators

1.7.1 Unbiased estimation: UMVUE

1.7.2 Method of Moments

1.7.3 Maximum likelihood estimation

1.7.3.1 Likelihood function

1.7.3.2 Regularity conditions

1.7.3.3 Finding maximum likelihood estimator

1.7.3.4 Score function, Fisher information and Variance

1.7.3.5 Lower bound for variance: Cramer-Rao inequality

1.7.3.6 Optimum properties of maximum likelihood estimator

1.7.3.7 Obtaining maximum likelihood estimator without differentiation

1.7.3.8 UMVUE and maximum likelihood estimator

1.7.4 Bayesian method

1.7.4.1 Prior and posterior distributions

1.7.4.2 Finding Bayesian estimator

2. Interval Estimation (10 lecture hours)

2.1 Introduction: notion of interval estimation

2.2 Confidence Intervals: definition, length of confidence interval

2.3 Review of sampling distributions

2.3 Definition of pivotal quantity

2.4 Methods of finding interval estimates

2.4.1 Pivotal quantity method

2.4.1.1 Confidence interval for the mean (when population variance is known and unknown)

2.4.1.2 Confidence interval for the variance (when population mean is known and unknown)

2.4.1.3 Simultaneous confidence interval for the mean and variance

2.4.1.4 Confidence interval for the difference between two means for samples from two independent normal populations

2.4.1.5 Confidence interval for ratio of variances for samples from two independent normal populations

2.4.2 Large Sample Confidence Intervals

2.4.3 Bayesian Interval Estimates: credible interval

3. Parametric Tests of Hypotheses (15 lecture hours)

3.1 Review

3.1.1 Statistical hypothesis, null and alternative hypothesis, simple and composite hypotheses

3.1.2 Test of hypothesis, critical region, type I and type II errors, probabilities of type I and type II errors, problem of controlling these probabilities

1.1.3 Power function and size test

3.2 Simple null hypothesis versus simple alternative

3.2.1 Simple likelihood ratio test

3.2.2 Most powerful test

3.2.3 Neyman-Pearson lemma

3.3 Composite Hypotheses

3.3.1 Generalized likelihood ratio test

3.3.2 Uniformly most powerful test

3.3.3 Monotone likelihood ratio

3.4 Unbiased tests: definition

3.5 Examples using sampling from the normal population

3.5.1 Tests on the mean

3.5.2 Tests on the variance

3.5.3 Tests on equality of two and several means

3.5.4 Tests on two variances

3.6 Chi - Square Tests

3.6.1 Asymptotic distribution of generalized likelihood ratio test

3.6.2 Goodness-of-fit test

3.6.3 Test of independence in contingency tables

3.7 Relationship between Test of Hypotheses and Confidence Intervals

3.8 Sequential Tests of Hypotheses

3.8.1 Definition of sequential analysis and comparison with fixed sample test

3.82 Sequential probability ratio test

4. Nonparametric Methods (8 lecture hours)

4.1 Introduction

4.2 Inference concerning a cumulative distribution function

4.2.1 Sample or Empirical cumulative distribution function: definition and convergence

4.2.2 Kolmogorov-Smirnov goodness-of-fit test

4.3 Inference concerning quantiles

4.3.1 Definition of quantiles

4.3.2 Point estimate of a quantile

4.3.3 Interval estimate of a quantile

4.4 Equality of two distributions

4.4.1 Two-sample sign test

4.4.2 Run test

4.4.3 Median test

4.4.4 Rank-sum test

Textbook

Mood, Graybill, and Boes: Introduction to the theory of Statistics, 3rd Edition,

References

1. Casella, G. and Berger, R.L. (2001). Statistical Inference (2nd Edition). Duxbury press.
2. Cox, D.R. (2006). Principles of Statistical Inference. Cambridge University Press.
3. Hoel, P.G. Port, S.C. and Stone, C.J. (1972). Introduction to Statistical Theory. Houghton-Mifflin Series in Statistics.
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7. Mukhopadhyay, N. (2000). Probability and Statistical Inference. Statistics: a Series of Textbooks and Monographs. CRC.
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Teaching and Learning Methods

Lectures, tutorials and assignments.

Mode of Assessment and Evaluation

Two or more assignments & tests	20%
Mid Exam	30%
Final Exams	50%
Total	100%

Course title: **Introduction to Multivariate Methods**
Course code: **Stat 474**
Credit hours: **3**
Contact hours: **Lecture 3 hrs, Tutorial and Computer Lab 1 hour per week**
Pre-requisite:

Course description
Introduction; Review of Matrix algebra;Practical examples of multivariate data; Preliminary data analysis; Examination of a data matrix, reduction of a data matrix; definition and calculation of sample summary statistics: means, variances, covariance's, correlations; Examination and interpretation of sample correlation matrix; the multivariate normal distribution. Study of relationships (association); One-sample test of mean vector; simultaneous confidence intervals for detecting important components; test of structural relationsip; Extension to two-sample tests; principal components and factor analysis as a means of reducing dimensionality: Calculation and interpretation of principal components and common factors.

Objectives
- to equip students with sound knowldge of extending the statistical ideas of univariate data analysis to that of multivariate;
- to equip them with skills of computing multivariate methods;
- to motivate them to apply the multivariate methods to solve real life problems.

Learning outcomes
At the end of the course students are expected to:
- state the basic statistical ideas of multivariate data anlaysis;
- use the basic multivariate statistical methods and interpret them.

Course Outline

1. **Introduction (6 lecture hours)**
   1.1 Introduction
   1.2 Objectives
   1.3 Areas of application
   1.4 Organizing multivariate data
   1.5 Organization of data
   1.6 Descriptive statistics
   1.7 Measures of linear association
2. **Review of Matrix Algebra and Random Vectors (10 lecture hours)**
   2.1 Basics concepts
   2.2 Vector and matrix
   2.3 Matrix algebra
   2.4 Positive definite matrix
   2.5 Square root matrix
   2.6 Mean vectors and covariance matrices

2.7 Matrix inqualities and maximization

3. **Multivariate Normal Distribution (7 lecture hours)**
   3.1 Multivariate normal density
   3.2 Sampling from multivariate normal distribution
   3.3 Maximum likelihood estimation
   3.4 Sampling distribution of a sample multivariate mean and a covariance matrix
4. **Inference about a Multivariate Mean Vector (7 lecture hours)**
   4.1 Inference about a mean vector
   4.2 Hypothesis testing
   4.3 Hotelling's test statistic
   4.4 Confidence regions and simultaneous comparision of components
   4.5 Large sample inference about the mean vector
5. **Comparisions of Several Multivariate Means (4 lecture hours)**
   5.1 Paired comparisions and a repeated measures
   5.2 Comparing mean vectors from two populations
   5.3 Comparing several multivariate population means
6. **Principal components and Factor analysis (8 lecture hours)**
   6.1 Population principal components
   6.2 Summarizing sample variation by principal components
   6.3 Large sample inferences
   6.4 Common factors and estimation

Textbook

Johnson, R.A and Wichern, D.W. (2007). Applied Multivariate Statistical Analysis (6th Edition). Prentice-Hall, Inc., New Jersey.

References

1. Hair, J.F., Black, W.C., Babin, B.J., and Anderson, R.E. (2009). Multivariate Data Analysis (7th Edition).
2. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis (3rd Edition). Wiley, New York.
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9. Grimm, L.G. and Yarnold, P.R. (1995). Reading and Understanding Multivariate Statistics.
10. Manly, B.F.J (2004). Multivariate Statistical Methods: A Primer (3rd Edition).

11. Raykov, T. and Marcoulides, G.A. (2008). An Introduction to Applied Multivariate Analysis.

Teaching and Learning Methods

Lecture, self reading, demonstration, exercises.

Mode of Assessment and Evaluation

At least two tests and assignments	20%
Mid Semester Examination	30%
Final Examination	50%
Total	100%

Course title: **Categorical Data Analysis**
Course code: **Stat 476**
Credit hours: **3**
Contact hours: **Lecture 3 hours, Tutorial and Computer Lab 1 hr per week**
Pre-requisite:

Course description
Introduction; Contingency Tables: Probability, Comparing Proportions, Odds Ratio, Testing Independence; Multicategory Logit Models; Loglinear Models for Contigency Tables.

Objectives
The objective of the course is to discuss statistical methods and models appropriate to the categorical data.

Learning outcomes
Upon completion of this course students are expected to:

- Understand the most common discrete probability distributions used as a basis to the derivation of statistical methods for the analysis of categorical data,
- Define odds ratio and use to test independence of factors in multinomial sample.
- Test homogeneity of proportions,
- Use the Pearson's Chi-square test to examine independence of factors,
- Use likelihood ratio test to test independence of factors in three dimensional tables,
- Fit and interpret logistic regression, log-linear and Poisson models,
- Interpret multiple logistic regression coefficients,
- Use the common model building and diagnostics methods in multiple logistic regression modeling, and
- Use appropriate statistical software to analyze categorical data.

Course Outline

1. **Introduction (6 lecture hours)**
   1.1 Categorical Response Data
   1.2 Probability Distribution for Categorical Data
      1.2.1 The Binomial Distribution
      1.2.2 The Multinomial Distribution
      1.2.3 The Poisson Distribution
   1.3 Statistical Inference for a Proportion
   1.4 More on Statistical Inference for Discrete Data
      1.4.1 Wald, Likelihood- Ratio, and Score Inference
      1.4.2 Small-Sample Binomial Inference
2. **Contingency Tables (10 lecture hours)**
   2.1 Probability Structure for Contingency Tables
      2.1.1 Joint, Marginal, and Conditional Probabilities
      2.2.2 Independence
      2.2.3 Binomial and Multinomial Sampling

2.2 Comparing Proportions in two-by-two Sampling
2.3 The Odds Ratio
2.3.1 Inference for Odds Ratio
2.3.2 Odds Ratio and relative Risk
2.4 Chi-square Tests of Independence
2.4.1 Pearson Statistics and the Chi-Square Distribution
2.4.2 Likelihood-Ratio Statistic
2.4.3 Tests of Independence
2.5 Testing for Independence for Ordinal data
2.6 Exact Inference for Small Samples
2.7 Association in Three-Way Tables
2.8 Chi-square test of homogeneity
2.9 Chi-square test of goodness-of-fit

3. Logistic Regression (8 lecture hours)
3.1 The Logistic Regression Model
3.2 Inference for Logistic Regression
3.3 Logistic Regression with Categorical Predictors

4. Building and Applying Logistic Regression Models (6 lecture hours)
4.1 Model Selection
4.2 Model Checking

5. Multicategory Logit Models (6 lecture hours)
5.1 Logit Models for Nominal Responses
5.2 Cumulative Logit Models for Ordinal Responses

6. Loglinear Models for Contigency Tables (10 lecture hours)
6.1 Loglinear Models for Two-way tables
6.2 Loglinear Models for Three- way Tables
6.3 Three Factor Interaction
6.4 The Loglinear-Logistic Connection

7. Poisson regression model (2 lecture hours)
7.1 Introduction to Poisson regression
7.2 Estimation and testing

Textbook

Agresti, A. (2007) An Introduction to Categorical Data Analysis (2nd edition). Wiley, New Jersey.

References

1. Christensen, R. (1997). Log-linear models and logistic regression, second edition, Springer, New York.
2. Agresti A. (2002). Categorical Data Analysis. (2nd ed.), Wiley, New York.
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8. Allisson, P. (1999). Logistic Regression Using the SAS System. Cary, NC, SAS Institute.
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Teaching methods

Lecture; Reading Assignment, Exercises; Tutorial; Computer lab work (Analysis using relevant statistical software such as R).

Mode of Assessment

At least two tests and assignments	20%
Mid-semester Examination	30%
Final Examination	50%
Total	100%

Course Title: **Econometrics**
Course Number: **Stat 477**
Credit Hours: **3**
Contact hours: **Lecture 3 hrs, Tutorial and Computer Lab 1 hr per week**
Pre-requisite:

Course Description
Basic economic models: the nature and scope of econometrics; the relations among econometric theory, mathematics and statistics; steps in econometric analysis; The general linear model: assumptions, properties, inference about parameters; non Linear models; Problems in econometrics: heteroscedasiticity, autocorrelation, multicollinearity, errors in variables, dummy variables; lagged variables; simultaneous equation systems.

Objectives
- Introduce students to the basic concept of econometrics to demonstrate relationships between economic variables by means of statistical techniques.
- Examine the consequences of violation/failure of the assumptions of econometric models, the basic problems arising in analysis of economic data and methods for detecting and resolving the problems that arise due to violation of assumptions.
- Introduce multi-equation systems as a summary of economic activity and the possibilities of estimating the equations.

Learning Outcomes
At the end of the course students are expected to:
- have acquired enough theoretical knowledge about economic and econometric models;
- apply mitigation techniques to resolve violations of the basic assumptions in an econometric model;
- to identify important variables (from a larger pool of variables) need to be included in order to make an econometric model meaningful.

Course Outline

1. Introduction (8 lecture hours)
- 1.1 Definition of Econometrics
- 1.2 Economic Model Building
- 1.3 Scope and Objective of Econometrics
- 1.4 Steps in Econometric Analysis
- 1.5 Structural and reduced forms

2. Review of Multiple Regression and Problems in Econometrics (10 lecture hours)
- 2.1 Multiple Linear Regression
- 2.2 Heteroscedasticity
- 2.3 Autocorrelation
- 2.4 Multicollinearity

2.5 Errors in variables
2.6 Lagged variables
2.7 Further Model Peculiarities
2.7.1 Stochastic regressors
2.7.2 Model misspecification
2.7.3 Qualitative variables

3. Lagged Variables (8 lecture hours)

3.1 Sources of lagged variables
3.2 Estimation methods
3.3 Time-series methods

4. Further Topics (10 lecture hours)

4.1 Recursive residuals
4.2 Spline functions
4.3 Pooling of time-series and cross-sectional data
4.4 Variable-Parameter models
4.5 Qualitative dependent variables
4.6 Errors in variables

5. Simultaneous Equation Systems (12 lecture hours)

5.1 Some illustrative simultaneous systems
5.2 The identification problem
5.3 Relation between Identification and Estimation
5.4 Conditions for identification
5.5 Estimation of simultaneous equation models

Textbook

Johnson, J.(1984). Econometric Methods (3rd Ed.). McGraw-Hill, New York.

References

1. Chow, G.C. Econometrics (1983). McGraw – Hill, New York Dhrymes, P. Introductory Econometrics, Springer – Verlag, New York.
2. Gujarati, D. N. (2002). Basic Econometrics (4th edition). McGraw-Hill, Inc., New York.
3. Hill, R.C., Griffths, W.E. and Lim, G.C. (2007). Principles of Econometrics (3rd edition). John Wiley and Sons, New York.
4. Intriligator, M.D. (1978). *Econometric Models, Techniques, and Applications.*. Prentice-Hall, Englewood Cliffs, New Jersey.
5. Judge, G. G., Griffths, W. E., Hill, R. C. and Lutkepohl, H. (2001). The Theory and Practice of Econometrics (2nd Edition). Wiley and Sons, New York.
6. Koutsoyiannis, A. (208). Theory of Econometrics (2nd Edition), India.
7. Maddala, G.S. (1977). *Econometrics*. McGraw-Hill, New York.
8. Patterson, K. (2008). An Introduction to Applied Econometrics: A time Series Approach, …..
9. Ramanathan, R. (2002). Introductory Econometrics with Applications (5th edition). Hartcourt College Publishers.

10. Stock, J. H. and Watson, M. W. (2003). Introduction to Econometrics (2nd Edition). Addison-Wesley, New York.
11. Theil, H. (1971). Principles of Econometrics. John Wiley & Sons, New York.

Teaching and Learning Methods

Lecture, tutorial, assignment and computer laboratory practice.

Mode of Assessment and Evaluation

At least two tests and assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Operations Research**
Course code: **Stat 478**
Credit hours: **3**
Contact hours: **Lecture 3 hrs, Tutorial and Computer Lab 1 hr per week**

Course description
Introduction, Origin, Development, Meaning, Scope, Techniques, Phases and Limitations of Operations Research. Linear programming (Algebraic and Simplex methods); Sensitivity analysis; Duality theory in linear programming; Transportation problem; Queuing Theory; Game Theory.

Objectives
- To introduce the basic concepts of linear programming
- To present the basic theory of linear programming
- To develop a thorough understanding of linear programming algorithms
- To present the basics of transportation problem
- To introduce queuing and game theories.

Learning outcomes
Upon successful completion of this course students are expected to:
- understand the basics of linear programming, transportation problems, queuing and game theories;
- understand the application of operation research methods to real life problems.

Course Outline

1. Introduction (4 lecture hours)
1.1 The meaning of OR
1.2 The general nature of OR
1.3 The Major Phases of an OR Project
1.4 Classification of problems in OR
1.5 The Structure of OR Mathematical Models

2. Linear Programming (10 lecture hours)
2.1 Linear Programming problem (LPP)
2.2 Graphical Method Of Solution Of LPP In Two Variables
2.3 The Simplex Method Of Solution Of LPP
2.4 Tableau Form:
2.4.1. The Genearal Case
2.4.2 Greater Than Or Equal To Constraints
2.4.3. Equality Constraints
2.2.4. Eliminating Negative Right Hand Side Values
2.5 Solving A Minimization Problem
2.6 Special Cases
2.6.1 Infeasibility
2.6.2 Unboundedness

2.6.3 Alternative Optimal solutions
2.6.4 Degeneracy

3. Simplex Based Analysis And Duality (10 lecture hours)

3.1. sensitivity Analysis With The Simplex Tableau
3.2 The Range Of Optimality
3.3 The Range Of Feasibility
3.4 Duality
3.4.1 Economic Interpretation Of Dual Variables
3.4.2 Using The Dual To Identify the Primal Solution
3.4.3 Finding The Dual Of Any Primal Problem

4. Transportation Problem (8 lecture hours)

4.1 General linear programming model of the transportation problem
4.2 Balancing transportation tableau
4.3 Starting basic solutions (north – west comer method, least cost method)
4.4 Optimality test
4.5 Transportation algorithm; degeneracy, perturbating a degenerate basic feasible solution

5. Queuing Theory (12 lecture hours)

5.1 The Structure Of Waiting Line System
5.1.1 The Single Channel Waiting Line
5.1.2 The Process Of Arrivals
5.1.3 The Distributions Of Service Time
5.1.4 Queue Discipline
5.1.5 Steady State Operation
5.2 The Single channel Waiting Line Model With Poison Arrival and Exponential Service Time
5.2.1 The Operating Characterisitics
5.2.2 The Decision Maker's Use Of Waiting Line Models
5.2.3 Improving The Waiting Line Operation
5.3 Multiple Channel Waiting Line Model with Poison Arrival And Exponential Service Times: the Operating Characteristics and Their Interpretation.
5.4 Some General Relationships For Waiting Lines
5.5 Economic Analysis Of Waiting Lines
5.6 Other Waiting Line Models

6. Game theory (4 lecture hours)

6.1 Introduction
6.2 Pure and mixed strategies
6.3 Solving pure strategy games
6.4 Solving games with simplex methods
6.5 *2xn* and *mx2* games

Textbook

Taha, H.A. (2006). Operations Research: An Introduction (8th edition). Prentice-Hall, India, New Delhi.

References

1. Carter, M.W. and Price, C.C. (2000). Operations Research: A Practical Introduction CRC.
2. Philips, D. T., Ravindra, A. and Solberg, I. Operations Research Principles and Practice. John Wiley and Sons, New York.
3. Ravindran, A., Phillips, D.T. and Solberg, J.J. (1987). Operations Research: Principles and Practice. (2nd edition). Wiley.

Teaching and learning methods

Lectures, tutorials, discussions, presentation, computer lab practice.

Mode of Assessment

Two or more assignments & tests	20%
Mid-semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Statistical Quality Control**
Course code: **Stat 479**
Credit hours: **3**
Contact hours: **Lecture 3 hrs, Tutorial and Computer Lab 1 hr per week**

Course description
Introduction; Basic methods of statistical process control; Other statistical process-monitoring and control techniques; Acceptance sampling; Reliability and Life testing; Ethiopian experience in Statistical quality control.

Objective
To introduce the most common statistical methods for statistical quality control (SQC).

Learning outcomes
Upon the completion of the course students are expected to:

- Identify application of various Statistical quality tools,
- Specify the parameters and information needed to make SQC records useful for trouble-shooting and problem-solving,
- Use control chart techniques for quality improvement,
- Identify the regulatory and accreditation requirements for SQC for tests of interest,
- Perform a critical review of laboratory practices for planning, establishing, and operating a SQC procedure,
- Select control materials that are appropriate for tests of interest,
- Calculate SQC statistics,
- Carry out reliability tests,
- Evaluate the status of Ethiopian experience in statistical quality control.

Course outline

1. **Introduction (6 lecture hours)**
   1.1 Quality Improvement in the Modern Business Environment
   1.2 Modeling Process Quality.
2. **Methods of Statistical Process Control and Capability Analysis (21 lecture hours)**
   2.1 Methods and Philosophy of Statistical Process Control.
   2.2 Control Charts for Variables.
   2.3 Control Charts for Attributes.
   2.4 Process and Measurement System Capability Analysis.
3. **Other Statistical Process-monitoring and Control Techniques (10 lecture hours)**
   3.1 Cumulative Sum and Exponentially Weighted Moving Average Control Charts.
   3.2 Other Univariate Statistical Process Monitoring and Control Techniques.
   3.3 Multivariate Process Monitoring and Control.
4. **Acceptance Sampling (4 lecture hours)**
   4.1 Concepts of acceptance sampling
   4.2 Lot-by-lot acceptance sampling for attributes
   4.3 Other acceptance sampling techniques

5. Reliability and Life Testing (4 lecture hours)

5.1 Definition of reliability
5.2 Life history curve
5.3 Types of reliability tests

6. Ethiopian Experience in Quality Control (2 lecture hours)

Discussion on the Ethiopian industry experience in quality control.

Textbook

Montogomery D. C. (2005) Introduction to Statistical Quality Control (5th Edition) Arizona State University.

References

1. Chang D. and Macmillan S. (1992). Statistical Quality Design and Control. Contemporary Concepts and Methods.
2. Donald J. (1992). Statistical Process Control (2nd edition). SPS Press.
3. Lenz, H.-J. and Wilrich, P.-TH (2004). Frontiers in Statistical Quality Control. Wiley, New York.
4. Thomas P. R. (2000). Statistical Methods for Quality Improvement,(2nd edition). Wiley, New York.
5. Vardeman, S.B. (1994). Statistics for engineering problem solving. Boston: PWS.
6. Vardeman, S.B., & Jobe, J.M. (1999). Statistical quality assurance methods for engineers.
7. Vardeman, S.B., & Jobe, J.M. (2001). Basic engineering data collection and analysis. Pacific Grove, CA: Duxbury.
8. Westgard J. O. (2002). Basic QC Practices (2nd edition)

Teaching methods

Lecture, reading assignment, exercises and tutorial.

Mode of Assessment

Two or more tests & assignments	20%
Mid-semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Sampling Practice**
Course code: **Stat 485**
Credit hours: **2**
Pre-requisite: **Stat 372**

Course description
Planning a sample survey; Preparation of sampling frames; Choice of design; Selection process and estimation procedures; Strategies and methods of data collection; Questionnaire design; Survey cost estimation; Pilot surveys and pretests; Organization of field work; Supervision and quality checking; Data Processing; Analysis and Presentation of Findings; Non-Sampling Errors and adjustment; Application of sample survey practice.

Course Outline

1. Planning for sample survey (1 lecture Hr)
1.1 Why planning?
1.2 Major items of the plan: Sample survey design, Human resource, Financial, Logistics etc.

2. Preparation of sample frames (2 **lecture** hours**)**
2.1 Definition of frames
2.2 Types of sampling frames
2.2 Frame structures

3. Sample Design (2 lecture hours)
3.1 Choice of design
3.2 Selection process
3.3 Estimation procedures

4. Methods of data collection (1 lecture Hr **)**
4.1 Dimension of study
4.2 Types of sample survey

5. Instruments of data collection (3 lecture hours)
5.1 Types of instruments
5.2 Principle of questionnaire design
5.3 Types of questionnaire
5.4 Questionnaire layout
5.5 Open versus closed questions
5.6 Common problems of questionnaire writing
5.7 Choice of reference period

6. Pre-tests and pilot survey (1 lecture Hr)
6.1 Pre-tests
6.2 Pilot survey
6.3 Specific uses of pilot survey

7. Survey Cost Estimation (1 lecture Hr)
7.1 Time scheduling
7.2 Preparation of budget proposal

8. **Field Work (1 lecture Hr)**
   8.1 Organization of field work
   8.2 Recruitment of field workers
   8.3 Training of field workers
   8.4 Management of field work
   8.5 Supervision and quality checks
9. **Survey Analysis (1 lecture Hr)**
   9.1 Preparations for data analysis
   9.2 Analysis of data
   9.3 Presenting the results
10. **Non-sampling Error in Surveys** (1 lecture Hr)
    10.1 Classification of survey error
    10.2 Classification of non-sampling error
11. **Ethiopian Central Statistics Agency (ECSA) (2 lecture hours)**
    Mandate; Scope of activities; Experience with regard to sample survey design, Logistics and Data analysis, Existing reports. Technical staff may be invited to share their experience
12. **Application of Sample Survey Practice (16 lecture hours)**
    Students will define, design, and conduct a sample survey. They also analyze the data, and present the survey report both orally and in written form.

Textbook:

Kumar, R. S.(1996). Practical Sampling Technique (2nd, Edition). Marcel Deker, New York.

References

1. Thompson, S. K. (2002). Sampling, 2nd, ed, Wiley, New York.
2. Chochran, W. G. (1977). Sampling Techniques, 3rd Ed, John Wiley& Sons, Inc., Newyork
3. Cotter, J. and Nealon, J. (1987). Area Frame Design for Agricultural Surveys. National Agricultural Statistics Service, USDA, Washington.
4. FAO(1996). Conducting Agricultural Censuses and Surveys, FAO Statistical Development Series N0. 6, Rome.
5. Vogel, F. A. (1986). Sample Design and Estimation for Agricultural Sample Surveys. Statistical Reporting Service, NASS/USDA, Washington.
6. Hansen, M. H., Hurwitz, W. N. and Madow, W. G. (1953). Sample Survey Methods and Theory. Vols. I-II, New York: John Wiley& Sons.
7. UN (1992). Handbook of Population and Housing Censuses: Part I, Planning, Organization, and Administration of Population and Housing Censuses. Studies in Methods, Ser. F, No. 54
8. UN (1982). Non-sampling errors in Household Surveys: Sources, Assessment and Control. NHSCP Technical Study.
9. FAO (1995). Multiple Frame Agricultural Surveys-Agricultural Surveys based on area and List Sampling Methods. FAO Statistical Development Series N0. 7, Rome.

10. Henry, G. T. (1990). Practical Sampling. Applied Social Research Methods Series. Sage: Newbury Park, CA.

Mode of Assessment

Written Examination	50%
Sample survey project	
Written report	35%
Oral presentation	15%
Total	100%

Course title: **Introduction to Statistical Modelling**
Course code: **Stat 486**
Credit hours: **3**
Contact hours: **Lecture 2 hrs, and Tutorial & Comp Lab 3 hrs per week**

Course description
Basic concepts of statistical modelling; Principles of statistical modeling; Family of statistical models; Theoretical and empirical considerations. Simple applications of statistical models in real problems. Statistical methods to be addressed are probability distributions, regression analysis, logistic regression, multivariate, exploratory and confirmatory factor analysis. MINITAB and R Software will be used.

Objectives
The objectives of the course are:

- to provide students with basic statistical knowledge and skills in statistical modelling;
- to equip students with skills of modelling and simulation of real life problems;
- to enhance statistical thinking of students in solving problems.

Learning outcomes
At the end of the course students are expected to:

- demonstrate the idea of statistical modelling;
- model data coming from real life problems;
- simulate a model giving a number of realization and interpretation;
- demonstrate statistical thinking.

Course Outline

1. **Basic Concepts of Statistical Modelling (6 lecture hours)**
   1.1 Introduction
   1.2 Statistical data and modelling ideas
   1.3 Principles of statistical modeling
   Problem identification, Model formulation, Model fitting, Model validation
   1.4 Modelling approach in teaching statistics
2. **Family of Statistical Models (6 lecture hours)**
   2.1 Single statistical models
   2.2 Family of models
   2.3 The idea of model selection
3. **Theoretical and Empirical Considerations (12 lecture hours)**
   3.1 Data-and-then model approach
   3.2 Model-and-then data approach
   3.3 Illustrations in R and MINITAB Software
4. **Some Applications of Statistical Modelling to Real Problems (24 lecture hours)**
   4.1 Probability distribution models
   Real application examples and simulation exercises

4.2 ANOVA models
Real application examples and simulation exercises
4.3 Linear regression models
Real application examples and simulation exercises
4.4 Logistic regression models
Real application examples and simulation exercises
4.5 Applications in MINITAB and R Software

Textbook

1. Cox, R.D. and Snell, E.J., (1981).Applied Statistics: Principles and Examples.
2. Krzanowski, W.J. (1998). An Introduction to Statistical Modelling.

References

1. Kleinbaum, D.G., (1998). An Introduction to Statistical Modelling.
2. Dobson, A.J. (1983). An Introduction to Statistical Modelling.
3. Dobson, A.J. (2002). An Introduction to Generalized linear models.
4. Pawitan, Y. (). In All Likelihood: Statistical Modelling and Inference Using Likelihood.
5. Chatfield, C. (). Problem Solving - A Statistician's Guide.
6. Neter, J., Kutner, M.H., Nachtsheim, C.J. and Wasserman, W. (1996). Applied Linear Statistical Models.
7. Montgomery, D.C. and Peck, E.A. (2001). Introduction to Linear Regression Analysis.
8. Venables, W.N. and Ripley, B.D. (2002). Modern Applied Statistics with S.
9. Aitkin, M., Francis, B., Hinde, J. and Darnell, R. (2009). Statistical Modelling in R.
10. MINITAB manuals.

Teaching and Learning Methods

Lecture, self reading, demonstration, exercises, practice using computer software.

Mode of Assessment

At least two tests and assignments	20%
Mid-semester exam Final Exam	30%
Final exam	50%
Total	100%

Course title: **Project I: Statistical Consultancy and Research Methods**
Course code: **Stat 487**
Credit hours: **2**
Pre-requisite: **Stat 376, Stat 378, Stat 379**

Course description
This course addresses issues related to research skill development with special reference to scientific paper writing including Research proposal, literature review, Materials and Methods, Result, Discussion, Conclusion, Reference, Citation and Report writing etc. It also briefly discusses about principles underling Statistical consultancy. The course is concluded with a research problem statement by each student and writing up a research proposal.

Objectives
- To discuss scientific procedures of proposal and research paper writing.
- To present principles underling statistical consultancy.

Learning outcomes
After completing the course students are expected to
- successfully apply scientific paper writing procedures in their research proposals and research paper reports.
- apply principles of good consulting practice in their future career.

Course Outline

1. **Statistical Consultancy (8 lecture hours)**
   2.1 General discussion of statistical consulting
   2.2 The role of the statistician in the experimental process;
   2.3 The tools and training necessary for statistical consulting;
   2.4 Principles of good practice of statistical consulting
   2.5 Consulting practice
2. **Research Methods (8 lecture hours)**
   1.1 Introduction: Concepts and definition of research
   1.2 Stating Research Problem
   1.3 Literature Review
   1.4 Materials and Methods
   1.5 Result
   1.6 Discussion
   1.7 Conclusion
   1.8 References and citation
   1.9 Research Proposal Writing
3. **Research Proposal Development**
   Students state research problem and write proposal.

Teaching and learning methods
Lecture, Reading assignments, group discussions and presentations.

Textbooks

Cabrera, J. and McDougall, A. (2001). Statistical Consulting, Springer, New york.

References

1. Boen, J. R. (1982), A self-supporting university statistical consulting center. The American Statistician, 36, 321-325.
2. Chatfield (1995). Problem solving: A statistician's guide. Chapman & Hall.
3. Derr, J. (2000). Statistical Consulting: A Guide to Effective Communication. Duxbury Press.
4. Kenett, R. and Thyregod, P. (2006). Aspects of statistical consulting not taught by academia. Statistica Neerlandica, **60**, 396-422.
5. Kirk, R. E. (1991), Statistical consulting in a university: Dealing with people and other challenges. The American Statistician, 45, 28-34.
6. Lenth, R. V. (2001). Some practical guidelines for effective sample size determination. The American Statistician, **55**, 187-193.
7. Parker, R. A. (2000). Estimating the value of an internal biostatistical consulting service. Statistics in Medicine, **19**, 2131-2145.
8. Pfannkuch, M. and Wild, C. J. (2000). Statistical thinking and statistical practice: themes gleaned from professional statisticians. Statistical Science, **15**, 132-152.
9. Shade J. (1996). Earning by Numbers: Starting a Statistical Consultancy. The Statistical Consultant, Volume 13, No. 3.
10. Strickland, H. (1996). The nature of statistical consulting. The Statistical Consultant, 13, 2-5.
11. Tweedie, R. (1998). Consulting: real problems, real interactions, real outcomes. Statistical Science, **13**, 1-29.

Mode of Assessment

Two or more tests & assignments	20%
Mid-semester Exam	30%
Research Proposal	50%
Total	100%

Course title: **Project II: Research in Statistics**
Course code: **Stat 488**
Credit hours: **2**
Pre-requisite: **Stat 487**

Course description
This is a continuation of Stat 487. Students Collect data, analyse, interpret results and write a research paper, which reflects the methods used, and the findings. Students present their work both orally and in written form.

Objective
The objective of this course is to demonstrate how to conduct statistical research and research paper writing.

Learning outcome
After completing the course students are expected to:

- Carry out investigations using statistical techniques
- Communicate effectively the results of statistical analysis.

Teaching and Learning Method
Discussion, Research work under supervision of a senior staff.

Mode of Assessment

Written research report	
Methodology	25%
Interpretation of results	25%
Report format	20%
Oral presentation	
Presentation	15%
Response to questions	15%
Total	100%

Course title: **Social and Economic Statistics**
Course code: **Stat 491**
Credit hours: **3**
Contact hours: **Lecture 3 Hours per week**
Pre-requisite:

Course description
Labor statistics: Gross and refined labor force participation rate classified by economic sectors, measures of urban and rural unemployment, wages and salaries classified by type of employment, education level, sex and region; Education Statistics: level of education, sex, region and occupation; measurement and evaluation; Economic statistics: index numbers, social account; Case studies.

Objectives
- to introduce students to some basic concepts of social and economic statistics;
- to enable students to use statistical methods for solving social and economic problems.

Learning outcomes
At the end of the course students are expected to:
- understand the basic concepts in social and economic statistics;
- apply statistical theories and methods to analyse and report results about social problems.

Course Outline

1. **Introduction (2 lecture hours)**
   1.1 Basic concepts and definitions
   1.2 Purpose of labor, education and economic statistics
   1.3 Principles of labor, education and economic statistics

2. **Labor Data and Analysis (8 lecture hours)**
   2.1 Labor force
   2.2 Economically active and inactive population
   2.3 Activity rate
   2.4 Labor force participation rates
   2.5 Employment status and unemployment rate
   2.6 Methods of data collection on wages and salaries of employees
   2.7 Inferences and modelling of labor data
   2.8 Case studies
3. **Education Data and Analysis (8 lecture hours)**
   3.1 Statistical data in education
   3.2 Ratios and percentages
   3.3 Dropout, retention, gross enrollment and net enrollment rates
   3.4 Inferences and modelling of education data

3.5 Case studies

4. **Economic Data and Analysis**

4.1 Index numbers **(12 lecture hours)**

4.1.1. Definitions, characteristics and uses
4.1.2. Types of Index numbers: price, quantity and value
4.1.3. Methods for constructing index numbers: Jevons, Dutot and Carli
4.1.4. Weighted aggregate index: laspeyres, Pachee, Young and Fisher
4.1.5. Tests of Adequecy of various index methods

4.2 **Consumer Price Index Number (6 lecture hours)**

4.2.1. Uses of Consumber Price Index number
4.2.2. Methods of compiling Consumber Price Index number
4.2.3. Methods of computing inflation rates
4.2.4. Interpretations of results

4.3 Social Accounts and Measures of National Accounts (12 lecture hours)

4.3.1. The nature of social accounts and classification of economic transaction
4.3.2. Contents of national income accounts
4.3.3. Gross Domestic Products and methods of aggregation
4.3.4. Gross National Products and methods of aggregatation
4.3.5. Problems and methods of imputation
4.3.6. Uses of social accounts matrices
4.3.7. Input- output table
4.3.8. Supply and use table

Textbooks and References

1. Hood, R. P. (2003) Statistics for Business and Economics (3rd edition).
2. Agrawel, B.L. (1996). Basic Statistics (3rd edition).
3. United Nation (1993). System of National Accounts.
4. IMF Manual. Methods of Computing Index Numbers.
5. Central Statistical Agency (2007). Ethiopian Consumer Price Index.
6. Ethiopian Ministry of Finance and Economic Development Report
7. Ethiopian System of National Accounts.

Teaching and Learning Methods

Lectures, demonstrations and assignments.

Mode of Assessment

Two or more tests and assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Biostatistics and Epidemiology**
Course code: **Stat 493**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week**
Pre-requisite:

Course description
Review of probability and statistics with applications in biomedical sciences: probability and odds, estimation, parametric and nonparametric tests; basic principles and methods of epidemiology; measures of disease occurrence: incidence rates, prevalence rates, odds ratio and relative risks; disease screening: sensitivity and specificity; and study designs: case-control, cohort and cross-sectional studies; survival analysis; clinical trails; research ethics.

Objectives
- to introduce the application of probabilistic and statistical ideas and methodologies to biological and medical researches;
- to introduce basic principles and methods of epidemiology and demonstrate their applications to basic biological, medical and public health problems.

Learning outcomes
Upon successful completion of this course students are expected to:
- describe different types of studies used in biomedical research;
- recognize the advantages and limitations of the different study designs;
- identify sources of bias in different study designs;
- define time-to-event data;
- understand why survival (time- to-event) data requires special analytic techniques;
- construct the Kaplan-Meier estimate for survival function to describe the survival experience of a cohort of subjects;
- interpret the result of a log-rank test in the context of comparing the survival experience of multiple cohorts;
- define and calculate sensitivity, specificity, negative predictive value and positive predictive value;
- calculate and interpret odds ratios, risk ratios and hazard ratios;
- understand research ethics in clinical studies.

Course Outline

1. **Review of Probability and Statistics with applications in biomedical sciences (12 lecture hours)**
   1.1 Probability
   1.2 Conditional Probability
   1.3 Bayesian Probability
   1.4 Odds and Probability
   1.5 Estimation: Point and Interval estimation
   1.6 Test of hypothesis

1.6.1 One-sample
1.6.2 Two-samples: Independent and paired samples
1.6.3 Non-parametric tests
1.6.4 Chi-Square test for contingency tables
1.6.5 McNemar Test
1.6.6 Comparing more than two means: ANOVA and multiple comparisions
1.6.7 Kruskal-Wallis Test to Compare Several Groups

2. **Principles and Methods of Epidemiology (9 lecture hours)**
   2.1 The Uses of Epidemiology
   2.2 Some Epidemiologic Concepts: Mortality Rates
   2.3 Age-Adjusted Rates
   2.4 Incidence and Prevalence Rates
   2.5 Measures of Relative Risk
   2.6 Odds Ratio
   2.7 Response Bias
   2.8 Confounding Variables
   2.9 Matching
3. **Designing Research (8 lecture hours)**
   3.1 Introduction
   3.2 Categories of research design
   3.3 Design of experiments
   3.4 Random allocation
   3.5 Minimization
   3.6 Observational studies
   3.7 Case-control study
   3.8 Cohort study
   3.9 Cross-sectional study
   3.10 Studies of change over time
   3.11 Choosing a study design
4. **Survival Data Analysis (10 lecture hours)**
   4.1 Introduction: time-to event, censoring, hazard function andsurvival function
   4.2 Kaplan-Meier estimates of survival probabilities
   4.3 Comparing survival curves in two groups
   4.5 Parametric survival models: Exponential and Weibull
   4.4 Introducing modeling survival data using Cox regression model
   4.5 Design of survival studies
5. **Disease Screening (3 lecture hours)**
   5.1 Sensitivity and specificity
   5.2 Negative predictive value, positive predictive value and related concepts
   5.2 Cutoff point and its effects on sensitivity and specificity
6. **Clinical Trials (3 lecture hours)**
   6.1 Features of randomized clinical trials
   6.2 Purposes of randomization
   6.3 Randomized assignment

6.5 Clinical trial as "Gold Standard"
6.8 Sample size for clinical trials

7. **Research Ethics and Statistics (3 lecture hours)**
   7.1 Introduction
   7.2 Protection of human research subjects
   7.3 Informed consent
   7.4 Research integrity
   7.5 Authorship policies
   7.6 Data and safety monitoring

Textbook

Wassertheil-Smoller, S. (2004). Biostatistics and Epidemiology: A Primer for Health and Biomedical Professionals (3rd edition). Springer, New York.

References

1. Campbell, M.J. and Machin, D. (1999). Medical Statistics: A Commonsense Approach (3rd edition). John Wiley & Sons, Chichester.
2. Altman, D.G. (1991). Practical Statistics for Medical Research. Chapman and Hall, London.
3. Gordis, L. (2004). Epidemiology (3rd edition), Saunders, Philadelphia.
4. Lee, E.T. and Wang, J.W. (2003). Statistical Methods for Survival Data Analysis. (3rd Edition). Wiley Series in Probability and Statistics.
5. Everitt, B.S. (2007). Medical Statistics from A to Z: A Guide for Clinicians and Medical Students (2nd edition). Cambridge University Press.
6. Riffenburgh, R.H. (2005). Statistics in Medicine (2nd edition). Academic Press.
7. Rosner, B. (2005). Fundamentals of Biostatistics (6th edition). Duxbury Press.
8. Glantz, S. (2005). Primer Biostatistics (6th edition). McGraw- Hill Medical.
9. Rothman, K.J., Greenland, S. and Lash, T.L. (2008). Modern Epidemiology (3rd edition). Lippincott Williams and Wilkins.
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Teaching and learning methods

Lectures, assignments and computer labs.

Mode of Assessment

Two or more assignments and tests	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Actuarial Statistics**
Course code: **Stat 494**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week**
Pre-requisite:

Course description
Definitions and concepts: insurance, risk, premium; Role of statistics in insurance; Concept of utility function; Feasibility of insurance business; Survival Distributions and Life tables; Models for Life Insurance: theory of compound interest, interest, instantaneous rate of interest, discount factor, actuarial present value, derivation of actuarial present value; Annuities**;** Benefit Premiums.

Objective

The objective of this course is to introduce the basic principles and methods in actuarial statistics and demonstrate their applicability in insurance.

Learning outcomes
Upon successful completion of this course students are expected to:

- understand the basic principles and methods in actuarial statistics;
- apply these methods to real life insurance problems.

Course Outline

1. **Insurance Business (6 lecture hours)**
   - 1.1 Insurance companies as business organizations
   - 1.2 Role of insurance business in Economy
   - 1.3 Concept of risk, types of risk, characteristics of insurable risk
   - 1.4 Working of insurance business, introduction of terms such as premium, policy, policyholder, and benefit
   - 1.5 Role of Statistics in Insurance
2. **Feasibility of Insurance Business (7 lecture hours)**
   - 2.1 Measurement of adverse financial impact, expected value principle
   - 2.2 Concept of utility function
   - 2.3 Feasibility of insurance business
   - 2.4 Illustrative Examples
3. **Survival Distributions and Life Tables (12 lecture hours)**
   - 3.1 Time-to-event random variable, its distribution function and survival function in actuarial notation
   - 1.2 Force of mortality
   - 1.3 Interrelations among distribution function, survival function, force of mortality and probability density function
   - 1.4 Construction of life table using random survivorship approach
   - 1.5 Uniform distribution assumption for fractional ages
   - 1.6 Some analytical laws of mortality

5 Models for Life Insurance (7 lecture hours)

4.1 Compound interest, interest, instantaneous rate of interest, discount factor

4.2 Insurance payable at the moment of death as well as at the end of the year of death, present variable, actuarial present value

4.3 Derivation of actuarial present value for *n*-year term life insurance, whole life insurance and Endowment insurance.

6 Annuities (10 lecture hours)

5.1 Annuities-certain, annuity due, annuity immediate, Life annuities

5.2 A whole life annuity, present value random variable of the payment, its actuarial present value using current payment technique

5.3 *n*-year temporary life annuity, its present value and actuarial present value

7 Benefit Premiums (6 lecture hours)

6.1 Concept of a loss random variable

6.2 Equivalence principle

6.3 Derivation of fully continuous premium for a unit whole life insurance payable immediately on death and for n-year term insurance.

Textbook

Borowiak D.S. (2003). Financial and Actuarial Statistics: An introduction. Statistics: a series of Textbooks and Monographs, CRC.

References

1. Boland, P.J. (2007). Statistical and Probabilistic Methods in Actuarial Science. Interdisciplinary Statistics, Chapman and Hall/CRC.
2. Bowers, N. L., Gerber, H.S., Hickan, J. C., Jones, D. A. and Nesbitt C. J. (1997). Actuarial Mathematics Chapters 1,3,4,5,6. The Society of Actuaries.

Teaching and learning methods

Lectures, assignments and computer labs.

Mode of Assessment

Two or more assignments and tests	20%
Mid-Semester Exam	30%
Final Exam	40%
Total	100%

Course title: **Applied Spatial Statistics**
Course code: **Stat 496**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week**
Pre-requisite:

Course description
Basic concepts; exploratory data modeling and analysis of point patterns, lattice data, image data; Geostatistics: random fields, variograms, autocorrelation; spatial linear interpolation (kriging), some illustrations from areas of environmental science, agriculture and forestry, demography, medicine, public health, mining, petroleum engineering, natural resources, geography; Applications using R Software.

Objectives
- to equip students with basic knowledge on design and analysis of spatial data;
- to equip students with skills of applying spatial statistics to real problems;
- to enable students to employ standard software for related computations.

Learning outcomes
At the end of the course students are expected to:
- demonstrate basic concepts, theories and methods in spatial statistics;
- model and simulate spatial data;
- apply statistical software for analyzing data and interpretation.

Course Outline

1. **Introduction (8 lecture hours)**
   1.1 Basic concepts
   1.2 Stochastic processes: definition and examples
   1.3 Spatial data
   1.4 Spatio-temporal data
   1.5 Visualization and exploration of the data
   1.6 Exploratory data modeling
2. **Spatial Data Analysis (10 lecture hours)**
   2.1 Point pattern and analysis:
   Clustering, spatial point processes, nearest neighbor statistics, second order statistics, bivariate and space-time point patterns
   2.2 Lattice data and analysis
   2.3 Image data and analysis
   2.4 Applications in R software
3. **Geostatistical Analysis of Spatial Data (10 lecture hours)**
   3.1 Random fields
   3.2 Variogram, semi-variogram, autocorrelation
   3.3 Estimation
   3.4 Applications in R software

4. **Kriging - Spatial Linear Interpolations (10 lecture hours)**
   4.1 Model specification
   4.2 Simultaneous and conditional models
   4.3 Estimation and simulation
   4.4 Applications in R software
5. **Illustrations (10 lecture hours)**
   5.1 Environmental science
   5.2 Agriculture and forestry
   5.3 Demography
   5.4 Medicine and public health
   5.5 Mining and petroleum engineering
   5.6 Natural resources
   5.7 Geography.

Textbook

1. Haining, R. (2003). Spatial Data Analysis: Theory and Practice.

References

1. Bailey and Gatrell, (1995). Interactive Spatial Data Analysis.
2. Bivand, R. S., Pebesma, E. J. and Gómez-Rubio, V. (2009). Applied Spatial Data Analysis with R (Use R).
3. Cliff, A. and Ord, J.K. (1981). Spatial Processes, Models and Applications. London: Pion.
4. Cressie, A. C. N. (1993). Statistics for Spatial Data.
5. Fortin, M. J. and Dale, M. R. T. (2005). Spatial Analysis: A Guide for Ecologists.
6. Illian, J., Penttinen, A., Stoyan, H. and Stoyan, D. (2008). Statistical Analysis and Modelling of Spatial Point Patterns (Statistics in Practice).
7. Ripley, B. D. (2004). Spatial Statistics.
8. Schabenberger, O. and Gotway, C. A. (2004). Statistical Methods for Spatial Data Analysis.
9. Venables, W. N., and Smith, D. M. (2008). An Introduction to R: Notes on R - A Programming Environment for Data Analysis and Graphics, Version 2.6.2.
10. Waller, L. A. and Gotway, C. A. (2004). Applied Spatial Statistics for Public Health Data.

Teaching and Learning Methods

Lectures, assignments and computer labs.

Mode of Assessment

Two o more tests or assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course title: **Statistical Ecology**
Course code: **Stat 497**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week**
Pre-requisite:

Course description
Basic concepts and definitions: ecology, statistical ecology; Population dynamics: growth models: linear, exponential, logistic, Gompertz and Leslie Matrix Models: fecundity and survival matrix, future projections, stable age distribution, application of these models; Smoothing Procedures: Poisson forest, Line transect method, Capture-recapture models and Removal method; Diversity Indices: Concept and need of Biodiversity, Indices: Richness, Simpson's and Shannon's index; Distribution Models: geometric and lognormal distributions.

Objective

The objective of this course is to introduce the basic principles and methods in statistical ecology and demonstrate their applicability in ecological and environmental data.

Learning outcomes
Upon successful completion of this course students are expected to:

- understand the basic principles and methods in statistical ecology;
- apply these methods to real life ecological and environmental problems.

Course Outline

1. **Population Dynamics (16 lecture hours)**
    - 1.1 Introduction: Ecology, Statistical Ecology
    - 1.2 Linear Growth Interpretation and limitation
    - 1.3 Exponential Model
        - 1.3.1 Solving Properties
        - 1.3.2 Interpretation
        - 1.3.3 Scope and Limitation
    - 1.4 Logistic growth model
        - 1.4.1 Density dependence
        - 1.4.2 Solving differential equation
        - 1.4.3 Carrying capacity
        - 1.4.4 Properties and interpretation
        - 1.4.5 Scope and limitation
    - 1.5 Gompertz Curve
        - 1.5.1 Solving differential equation
        - 1.5.2 Asymptotically stable equilibrium
        - 1.5.3 Properties and interpretation
        - 1.5.4 Scope and limitation

1.6 Leslie Matrix Models
    1.6.1 Fecundity and survival matrix
    1.6.2 Future projections
    1.6.3 Stable age distribution
    1.6.4 Interpretation of largest eigen value
1.7 Fitting the above growth models to data by linearization and regression.

2. Smoothing Procedures (16 lecture hours)

2.1 Poisson forest
    2.1.1 Regular spatial point pattern
    2.1.2 Estimation of population density by quadrant sampling
    2.1.3 Nearest neighbor distances
    2.1.4 Maximum likelihood estimate for Poisson forest, bias and standard error
2.2 Line transect method
    2.2.1 Drawing random line transect
    2.2.2 Exponential detection function
    2.2.3 Maximum likelihood estimate of population density
2.3 Capture-recapture models
    2.3.1 Closed and open populations
    2.3.2 Peterson estimator for single recapture
    2.3.3 Multiple captures
    2.3.4 Iterative method to find maximum likelihood estimate of population size
2.4 Removal method: Zippin's estimator for closed population.

3. Diversity Indices (8 lecture hours)

3.1 Concept of Biodiversity
3.2 Need to protect Biodiversity.
3.3 Richness indices
3.4 Simpson's index
3.5 Shannon's index
3.6 Rare-fraction curves, Real life examples for computing these indices.

4. Distribution Models (8 lecture hours)

4.1 Use of geometric distribution in Ecology
4.2 Use of lognormal distribution in Ecology

Textbook

Gore, A. P. and Pranajpe, S. A. (2002). A First Course on Mathematical and Statistical Ecology.

References

1. Georges, A. (1997). Introductory Statistics for Ecologists. Applied Ecological Research Group.
2. Gotelli, N. J. and Ellison A. M. (2004). A Primer of Ecological Statistics. Sinaver Associates.
3. Pielou, E. C. (1977). An Introduction to Mathematical Ecology. Wiley.

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5. Waite, S. (2000). Statistical Ecology in Practice: A Gide to Analyzing Environmental and Ecological Field data. Longman Group, United Kingdom.
6. Young, L. J. and Yong, J.(2009). Ecological Statistics. Springer.
7. Zuur A. G, Ieno E. N. and Smith G, M. (2007). Analyzing Ecological data: Statistics to Biology and Health. Springer.

Teaching and learning methods

Lectures, assignments and computer labs.

Mode of Assessment

Two or more assignments and tests	20%
Mid-Semester Exam	30%
Final Exam	40%
Total	100%

14.2 Supportive Courses

14.2.1 Computer Science Courses

Course Number: **Comp xxx**
Course Title: **Introduction to Computer Science**
Credit Hours: **3**
Contact hours: **Lecture 3 hours per week, Computer Lab 2 hours per week**
Prerequisites:

Course Description

An overview of Computer Science; the development of computers; data representation in computers; logical organization of a computer system; computer software and hardware; computer number system and arithmetic; computer system architecture; computer networks and communications with description of modern networking technologies; introduction to computer security.

Learning Outcomes

At the end of the course students are expected to:

- explain what Computer Science is and its characteristics and applications;
- explain the historical development, generations and types of computers;
- get acquainted with the computer system, data representation techniques, and computer arithmetic;
- get acquainted with the different coding methods;
- explain Boolean logic, logic elements, etc.;
- define computer networks and types;
- get acquainted with the internet and its services

Course outline

1. Overview of Computer Science (5 lecture hours)

1.1 Introduction to Information and Communication Technology (1/2 hour)
1.2 Definition of Computer and Computer Science (1/2 hour)
1.3 Characteristics of computers (1 hour)
- Speed, accuracy, capacity, versatility, durability and reliability

1.4 Types of computers (1 hour)
- Analog, digital, special purpose, general purpose
- Super computers, mainframe computers, minicomputers, microcomputers (desktop, laptop or notebook, PDA or palmtop, handheld)

1.5 Applications of computers (2 hours)
- Learning aid
- Entertainment
- Commercial and business applications

- Information utility
- Engineering and research applications
- Public service

2. Development of Computers (3 lecture hours)

2.1 History of computing (1 hour)
- Abacus
- Pascal's Calculator
- The difference engine and the analytical engine
- Herman Hollerith's tabulating machine
- Mark I
- ENIAC - Electronic Numerical Integrator And Computer
- The Von Neumann Machine
- Commercial computers

2.2 Generations of computers (2 hours)
- First, second, third, and fourth generations
- Current Trends

3. Organization of a Computer System (8 lecture hours)

3.1 Introduction to Computer Systems (1/2 hour)

3.2 Computer hardware (3 hours)
- The Central Processing Unit (CPU)
  - Purposes of the Central Processing Unit
  - Control Unit
  - Arithmetic and Logic Unit (ALU)
- RAM and ROM
- The bus system (address bus, data bus, and control bus)
- Input/Output units
  - Input units (pointing devices, game controllers, keyboard, scanner, camera, microphone)
  - Output units (monitor, printer, speaker)
- Storage units
  - Sequential access media (tape)
  - Random access media (magnetic disk, optical storage media, flash memory cards)

3.3 Computer software
- System software (3 hours)
  - Operating systems
    - What is an operating system?
    - Functions of an operating system (controlling operations, input/output management, command processing)
    - Types of operating systems (single/multi tasking, single/multi user, real-time, command driven vs GUI-based)
    - Example operating systems (Windows, UNIX, Solaris, MacOS)
  - Language software
    - Translators (assemblers, compilers, interpreters), and editors
- Applications software (1 1/2 hours)

- Word processing
- Spreadsheet
- Database management systems
- Graphics
- Software suites
- Enterprise application software

4 - Data Representation in Computers (12 lecture hours)

4.1 Units of data representation (1 1/2 hours)
- Bit, Byte, Word

4.2 Concept of number systems and binary arithmetic (4 hours)
- Binary, Octal, and Hexadecimal number systems
- Conversion from one number system to another
- Binary arithmetic

4.3 Coding method (2 1/2 hours)
- EBCDIC (Extended Binary Coded Decimal Interchange Code)
- BCD 4 and 6 (Binary Coded Decimal)
- ASCII 7 and 8 (American Standard Code for Information Interchange)
- UNICODE

4.4 Representation of negative numbers and arithmetic (3 hours)
- Signed magnitude, One's complement, Two's complement

4.5 Floating-point representation (1 hour)

5 - Computer System architecture (12 lecture hours)

5.1 Hierarchical structure of computer system architecture (1 hour)

5.2 Logic elements and Boolean algebra (3 hours)
- Logic gates and Boolean algebra

5.3 Implementation of Boolean algebra (3 hours)
- Boolean functions and truth tables
- Construction of logic circuits

5.4 Types of circuits (2 hours)
- Combinational and sequential circuits

6 - Computer networks and communications (4 lecture hours)

6.1 Introduction to computer networking and its applications (2 hours)

6.2 Types of networks
- LANs (Local Area Networks) and WANs (Wide Area Networks)

6.3 Introduction to tthe Internet (2 hours)
- Services of tthe Internet (e-mail, World Wide Web, file transfer/access, remote login/ execution, video conferencing)

7 - Computer security (4 lecture hour)

- Introduction to computer security
- Encryption
- Backup
- Viruses and worms

Textbook

Introduction to Computer Science, ITL Education Solutions Ltd., Pearson Education, 2004.

Mode of Assessment

Reading assignment	10%
Lab	20%
Mid-Semester Exam	20%
Final Exam	50%
Total	100%

Course Title: **Fundamentals of Programming**
Course Code: **Comp xxx**
Credit Hour: **3**
Contact Hours: **Lecture 3 hours per week, Computer Lab 2 hours per week**
Prerequisite:

Course Descriptions

Problem solving using computers; algorithms; program structure; constants; types; variables; reserved words; syntax diagram; identifiers; numbers; character strings and constant declarations; basic data types; statements (assignment, I/O, control).

Learning Outcomes

Upon completion of this course students are expected to:

- describe the problem solving process as applied in programming
- describe the basics of C++ programming – syntax and semantic elements of the programming
- describe and exercise the Arithmetic and Logic operations implemented in C++
- implement the program flow control in software
- describe and implement the basic data structure elements in C++ that serve as holding homogenous data primitives

Course Outline

1. **Introduction to Programming (12 lecture hours)**
    - 1.1 General Introduction to computer and programming
    - 1.2 Software Development Life Cycle (SDLC)
    - 1.3 Feasibility Study
    - 1.4 Requirement Analysis
    - 1.5 Designing Solution
    - 1.6 Testing Designed Solution
    - 1.7 Implementation(Coding)
    - 1.8 Unit Testing
    - 1.9 Integration and System Testing
    - 1.10 Maintenance
    - 1.11 Algorithm development and representation
        - 1.11.1 Structured Chart
        - 1.11.2 Pseudocode
        - 1.11.3 Flow chart
2. **C++ Basics (4 lecture hours)**
    - 2.1 Structure of C++ Program
    - 2.2 C++ IDE
    - 2.3 Showing Sample program
    - 2.4 Keywords, Identifiers, Inputs, Outputs, Comments, Parts of a program

2.5 Data Types, Variables, and Constants
2.6 Operators
    2.6.1 Assignment Operators
    2.6.2 Compound Assignment Operators
    2.6.3 Arithmetic Operators
    2.6.4 Relational Operators
    2.6.5 Increment and Decrement Operators
    2.6.6 Infix and postfix types
2.7 Precedence of Operators

3. Control Statements (16 lecture hours)

3.1 If statements: If…else, nested if
3.2 Switch Statements: Multiple cases, break, Default
3.3 Looping: for, while, do, break, continue
3.4 Nested Loops

4. Arrays and String Manipulation (12 lecture hours)

4.1 Array Definition
4.2 Array referencing
4.3 One dimensional and multidimensional arrays
4.4 Strings: Definition, accessing Strings

5. Pointers (4 lecture hours)

5.1 Definition of Pointers
5.2 Pointer and address of operator

Textbooks

1. Dietel and Dietel (2003). C How To Program (3rd Edition). Prentice-Hall.
2. Lafore, R. (1993). The Waite Group's C Programming Using Turbo C++. Techmedia.

References

1. Savitch, W. (1996). Problem solving with C++ – The Object of Programming. Menlo Park: Addison-Wesley.
2. Hubrard, J. R. (1997). Fundamentals of Computing with C++. Shuam's Outline.
3. Liberty, J. (1995). An Introduction to C++.
4. Lafore, R. (1994). The Wait Group Object Oriented Programming With C++.

Mode of Assessment

Lab Practical	20%
Mid-Semester Examination	30%
Final Examination	50%
Total	100%

Course Title: **Fundamentals of Database Systems**
Course Number: **Comp xxx**
Credit Hours: **3**
Contact hours: **Lecture 3 hours per week, Computer Lab 2 hours per week**
Prerequisite: **Comp xxx**

Course Description

Database systems concepts: definition of a database and benefits of database systems; Database Systems Architecture: Internal, conceptual and External level architectures; Relational data model: Conceptual data model- entity, attribute, relationship, and integrity constraints rules; Database design: ER-model, functional dependencies, avoidance of redundancy and normalization; Mapping ER-models to relational tables; Structured Query language-Data Definition Language, Data Manipulation Language; Basics of Relational Algebra and operation.

Learning Outcomes
At the end of the course students are expected to:

- Understand what a Database System is, and be able to identify its characteristics and applications,
- Explain the Different models of database,
- Design ER models from specifications and interpret them into relational tables,
- Write SQL statements for data creation and manipulation purposes,
- Know how to optimize databases to the most efficient form,
- Distinguish and use relational model and relational algebra,
- Identify and fix the possible problems that may occur in securing data,

Course Outline

1. **Introduction (2 lecture hours)**
   1.1 Overview
   1.2 Basics of Database
   1.3 File organization verses Database approach
   1.4 Users and actors of Database System
2. **Database System Architecture (5 lecture hours)**
   2.1 Data models, Schemas, and Instances
   2.2 Over view of data models
   2.3 DBMS Architecture and Data Independence
3. **The ER Model (10 lecture hours)**
   2.4 The high-level conceptual model
   2.5 Entities, Attributes, and Keys
   2.6 Relationships, Associations, and Constraints
   2.7 The ER Diagrams
   2.8 Mapping ER-models to relational tables

4. **Functional Dependency and Normalization (6 lecture hours)**
   - 4.1 Functional Dependency
   - 4.2 Normal Forms
5. **The SQL Language (10 lecture hours)**
   - 5.1 Data Definition Language
   - 5.2 Data Manipulation Language
   - 5.3 Basic Queries in SQL
   - 5.4 Views
6. **The Relational Data Model and the Relational Algebra (7 lecture hours)**
   - 6.1 The Relational Model Concepts
   - 6.2 The Relational Constraints and Relational Database Schemas
   - 6.3 The Relational Operations
7. **Data Protection (4 lecture hours)**
   - 7.1 Data recovery
   - 7.2 Concurrency
   - 7.3 Data Security

Textbook:

Elmasri, R. and Navathe, S, B. (2000). Fundamentals of Database Systems. Addison-Wesley.

References

1. Date, C. J. Introduction to Database systems.
2. Garcia-Molina, H., Ullman, J. D. and Widom, J. (2002). Database Systems The Complete Book. Prentice Hall.
3. Silberschatz, A, Korth, H. F. and Sudarshan, S. (2002). Database System Concepts (4th Edition). McGraw Hill.

Mode of Assessment

Tests	10%
Lab Evaluation and Project Work	20%
Mid-Semester Exam	30%
Final Exam	40%
Total	100%

14.2.2 Economics Courses

Course Number: **Econ xxx**
Course Title: **Introduction to Economics**
Credit Hours: **3**
Contact Hours: **Lecture 3 hours**
Prerequisite: **None**

Course Description

Basic topics in both microeconomics and macroeconomics; Microeconomics: scarcity, opportunity cost, the laws of demand and supply and elasticity, the functioning of a competitive market and the essence of short-run production theory and profit maximization; Macroeconomics: measurement and problems of economy-wide performance.

Objective

The objective of the course is to introduce students to the basic principles of economics.

Course Outline

1. Introduction (10 lecture hours)

1.1 Definition, scope and methods of economics
- 1.1.1 Definition of economics
- 1.1.2 The method of economics
- 1.1.3 The use of graphs and equations
- 1.1.4 The production possibility frontiers, efficiency and opportunity cost

1.2 Basic economic problems and the economic system
- 1.2.1 The basic economic problems and alternative economic system
- 1.2.2 Decision-making units and the circular flow of economic activities
- 1.2.3 Types of economic organizations and the stock markets

2. Microeconomics (19 lecture hours)

2.1 Supply and Demand
- 2.1.1 Perfectly competitive markets
- 2.1.2 Demand and supply functions, schedules and curves
- 2.1.3 Market equilibrium
- 2.1.4 Elasticity of demand and supply

2.2 Theory of production and costs
- 2.2.1 The short-run and the long-run
- 2.2.2 Short-run production functions: total, average and marginal products and the law of diminishing returns
- 2.2.3 Analysis of costs in the short-run: fixed, variable, total, average and marginal costs

2.3 The profit maximizing competitive firm
- 2.3.1 Revenue functions of a competitive firm
- 2.3.2 Rules of profit maximization

2.4 Review of market imperfections: monopoly, monopolistic competition and Oligopoly

3. Macroeconomics (19 lecture hours)

3.1 Problems of the macro economy

3.2 National Income Accounting

3.2.1 Basic concepts: Gross Domestic Product(GDP), Gross National Product (GNP)

3.2.2 Approaches to measuring GDP

3.2.3 Nominal and real GDP

3.2.4 National product and the informal economy

3.2.5 GDP and economic welfare

3.3 Aggregate demand and supply

3.4 Economic policy instruments: monetary, fiscal and income policy

Textbook

Samuelson, P. A. and Nordhaus, W. D. (1989). *Economics*, McGraw-Hill.

References

1. Ayele K. Introductory Economics, third edition, Addis Ababa Ethiopia.
2. Boumol, W. J. and Blinder, A. S. Economics: Principles and Policy, Harcout Brace, Jouncbich, Inc., New York.
3. Hyman, D. N. (1989), Economics, Trwin, Boston.
4. McConnel, C. R. Economics: Principles, Problems and Policies, McGraw-Hill, New York.

Mode of Assessment

Tests and assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course Number: **Econ xxx**
Course Title: **Introduction to Microeconomics**
Credit Hours: **3**
Contact Hours: **Lecture 3 hours**
Prerequisite:

Course Description
The neoclassical theory of consumer demand; consumer choice models: derivation and properties of individual demand and Engel. Curves: properties of market demand curves. Laws of production and costs; returns to scale; the law of variable proportions; choice of technique; short-run long-run cost. Theory of the firm and market equilibrium under market imperfection prick determination under market imperfection models of pure monopoly, Monopolistic competition. Price determination under Market imperfection: Oligopoly. Neoclassical models of factor demand and income determination. Introduction to general equilibrium and welfare economics. Introduction to the economics of information.

Course Outline

1. Demand, supply and market equilibrium (3 lecture hours)

2. Theory of utility and preferences (9 lecture hours)
- 2.1. The indifference curve
- 2.2. Characteristics of the indifference curve
- 2.3. Preferences and Demand
- 2.4. Marginal rate of substitution
- 2.5. The budget constraint
- 2.6. The consumers equilibrium

3. Theory of consumer behavior (6 lecture hours)
- 3.1. Maximization of satisfaction and limited money income
- 3.2. Shifting the budget line
- 3.3. Change in money income
- 3.4. The Engel curve
- 3.5. Change in price and the price consumption curve
- 3.6. Substitution and income effect

4. Theory of production (9 lecture hours)
- 4.1. Production with one variable input
  - 4.1.1. The production function
  - 4.1.2. Average and marginal product curves: relationship between MP and AP
  - 4.1.3. The stages of production
  - 4.1.4. The law of variable proportions
- 4.2. The optimal input proportions: two variable inputs
  - 4.2.1. The isoquants and isocosts

4.2.2. Substitution of inputs
4.2.3. Laws of returns to scale
4.2.4. The expansion path

4.3. The production function of a multi-product firm
4.3.1. The production possibility curve
4.3.2. The Iso revenue curve
4.3.3. Equilibrium of the multi-product firm

5. Theory of costs (6 lecture hours)

5.1. Short-run and the long-run
5.2. Short-run costs and the production function
5.3. Average and marginal costs
5.4. Long-run costs
5.5. Economies of scale

6. Theory of price under perfectly competitive markets (7 lecture hours)

6.1. Perfect competition: introduction and characteristics of perfect competition
6.2. Price determination in perfectly competitive market
6.2.1. Short-run equilibrium of a firm and an industry
6.2.2. Short run supply curve of the firm
6.2.3. Long-run equilibrium of a firm and an industry

7**. Theory of price in monopolistic markets (8 lecture hours)**

7.1. Definitions
7.2. Demand under monopoly
7.3. Short run equilibrium under monopoly
7.4. Monopoly supply in the short run
7.5. Price discrimination
7.6. Welfare effects of monopoly

Textbook

Koutsoyiannis, A. (1985). Modern Microeconomics (2nd edition) Macmillan.

References

1. Amacher, R. C. and Ulbrich, H. H. (1986). Principles of Microeconomics (3rd edition). South-Western Publishing Co., Cincinnati.
2. Gould, J. P. and Lazear, E. P. (1998). Microeconomic Theory (6th edition). Richard D. Irwin, Inc., Homewood.
3. Kreps, D. M. (1998). A Course in Microeconomics. Prentice Hall of India, New Delhi.
4. Lipsey, R. G. et al. (1993). Microeconomics (10th edition). Harper-Collins College Publishers, New York.
5. Singapore.

6. Stanlake, G. F. and Grant, S. J. (1995). Introductory Economics (6th edition). Longman,
7. Varian, H. R. (1993). Intermediate Microeconomics (3rd edition) Norton & Company, New York.

Mode of Assessment

Tests and assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Course Number: **Econ xxx**
Course Title: **Introduction to Macroeconomics**
Credit Hours: **3**
Contact Hours: **Lecture 3 hours**
Prerequisite:

Course Description

Concept of National Income Accounting; Review of controversies in macroeconomics; Micro foundation, adjustment to disequilibrium and price clearing; inter-temporal substitution, Micro based money demand formulation, Micro based labour market and a complete market clearing model, inflation in market clearing model; Issues of consumption (Simple Keynesian life-cycle and permanent income hypothesis), investment (the user cost, accelerator and Tobin - q) and growth (only one sector IIarrod-Domar).

Course Outline

1. Introduction
- 1.1. Definition, concepts and branches of Economics
- 1.2. Introduction to Macroeconomics
  - 1.2.1 Concept and definition of Macroeconomics
  - 1.2.2 Major Elements of Macroeconomics
- 1.3. State of Macroeconomics; Evolution and Recent Developments
  - 1.3.1 Classical and Neoclassical thoughts
  - 1.3.2 Keynesians
  - 1.3.3 Monetarism
  - 1.3.4 New classical School
  - 1.3.5 New Keynesian School

2. National Income Accounting
- 2.1. Definition and concept of 'National Income Accounting' process
- 2.2. General Introduction to Major Macroeconomic Models
- 2.3. Different Measures of National Income
  - 2.3.1 Real GDP versus Nominal GDP
  - 2.3.2 Gross Domestic Product (GDP) and
  - 2.3.3 Gross National Product (GNP)
  - 2.3.4 Other Values of Notional Accounts
- 2.4. Approaches to 'National Income accounting' process
  - 2.4.1 Value added approach
  - 2.4.2 Expenditure Approach
  - 2.4.3 Income Approach
  - 2.4.4 The Drawbacks/Shortcomings of GDP and/or GNP

3. Economic Performance and Business Cycle

3.1 Definition and Concepts of Business Cycle
3.2 Phases of Business Cycle
3.3 Business Cycle and Output Gap
3.4 Sources of Economic Fluctuations
3.5 Other Measures of Economic Fluctuations

4. Consumption Spending

4.1. Introduction; Consumption and Aggregate Demand
4.2. Consumption Function
4.3. Keynesian Consumption Puzzle
4.4. Derivation of saving function
4.5. Consumption Theories; Income and Consumption Relationship
4.5.1 Keynesian Absolute Income Hypothesis
4.5.2 Relative Income Hypothesis
4.5.3 Modigliani Life Cycle Hypothesis (Ando - Modigliani Approach)
4.5.4 Fisher's Intertemporal Model of Consumption
4.5.5 Permanent Income Hypothesis (Friedman Approach)

5. Investment Expenditure And Saving

5.1. Introduction

5.1.1 Definition and concept of Investment
5.1.2 Crowding Out Effect
5.1.3 Investment Criteria; The Decision to Invest
5.1.4 Why do people and government make investment?

5.2. Theories of Investment

5.2.1 Keynesian Marginal Efficiency of Capital (MEC)
5.2.2 Present Value criterion (PV) Vs Marginal Efficiency of Capital (MEC)
5.2.3 Investment Demand and interest Rate
5.2.4 Some Determinants of Investment in Less Developed countries
5.2.5 What is 'the Paradox of Thrift'?
5.2.6 Other Theories of Investment
5.2.7 Investment and saving (their relationship)

6. The Money Market

6.1. Introduction to Money and its Evolution
6.1.1 Value of Money and its Function
6.1.2 Classification or Types of Money
6.2. Money Supply; Components of money and Monetary Policies
6.2.1 What are the major components of money supply?
6.2.2 Income Velocity of Money and Quantity Theory
6.2.3 A simple Model of Money Supply
6.2.4 Money supply, Near Money and Seigniorage
6.2.5 Creation of Money and Banking System

6.3. Demand for Money:Theories of money demand

7. Labour Market and Employment Fluctuations

7.1. Introduction
7.2. Types of Unemployment: Phillips Curve Okun's Law
7.3. Labour Market Equilibrium and the Aggregate Supply curve
7.3.1 Labour supply and Business Cycle
7.3.2 Classical Frictionless Labour Market Equilibrium

Textbook

Dornbusch, R. and Fisher, S. (1994). Macroeconomics (2nd Edition). New York.

References

1. Ackley, G. (1987). Macroeconomics: Theory and Policy. McMillan.
2. Mankiw, G. (2000). Macroeconomics. Worth Publishing.
3. Shapiro, E. (2000). Macroeconomic Analysis (5th Edition). Harcourt Brace Jovanovich, Inc., New York.

Mode of Assessment

Tests and assignments	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

14.2.3 Mathematics Courses

Course Title: **Calculus I**
Course Code: **Math 264**
Credit hours: **4**
Contact Hours: **Lecture 4 hrs per week , Tutorial 2 hrs per week**
Prerequisite:

Course Description
This course introduces the basic concepts of limit; continuity; differentiation; integration, and some of their applications.

Course objectives
This course provides a firm foundation in the basic concepts and techniques of the differential and integral calculus.

Learning Outcomes
At the end of successful completion of the course, the students will be able to:

- understand the formal definition of limit and continuity,
- evaluate limits of functions,
- determine points of discontinuity of functions,
- apply Intermediate Value Theorem,
- evaluate derivatives of different types of functions,
- apply derivatives to solve problems,
- evaluate integrals of different types of functions,
- apply integrals to find areas and volumes.

Course Outline

1. Limits and Continuity (12 lecture hours)

1.1. ε-δ Definition of limit
1.2 Basic limit theorems
1.3 One-sided limits
1.4 Infinite limits and limits at infinity
1.5. Continuity
1.6. The Intermediate Value Theorem and its applications

2. Derivatives (18 lecture hours)

2.1 Definition of derivative
2.2 Tangent and normal lines
2.3 Properties of derivatives
2.4 Derivative of Functions (polynomial, rational, trigonometric, exponential, logarithmic and hyperbolic functions)
2.5 The Chain Rule
2.6 Higher order derivatives
2.7 Implicit differentiation

3. Applications of derivatives (16 lecture hours)

3.1 Extreme Values of functions
3.2 Rolle's Theorem, the Mean Value Theorem, and their application
3.3 Monotonic functions
3.4 The first and second derivative tests
3.5 Applications to extreme values and related rates
3.6 Concavity & inflection points
3.7 Graphing sketching
3.8 Finding roots of equations
3.9 L'Hopitals rule

4. Integrals (18 lecture hours)

4.1 Antiderivatives
4.2 Indefinite integrals and their properties
4.3 Partitions, upper and lower sum, Riemann sums
4.4 Definition and properties of the definite integral
4.5 The Fundamental Theorem of Calculus
4.6 Techniques of integration (integration by parts, integration by substitution, trigonometric integration, integration by partial fractions)
4.7 Application of integration: Area, volume of solid of revolution

Teaching and Learning Methods

Lectures, Exercises, and tutorials.

Modes of Evaluation

Assignment and quizzes	20%
Mid-Semester Exam	30%
Final Exam	50%
Total	100%

Textbook

Robert Ellis, Denny Gulick: Calculus with Analytic Geometry, 6th edition, Harcourt. Brace Jovanovich, Publishers.

Reference books

1. Adams R. A. (2003). Calculus: A Complete Course, 5th edition. Addison Wesley Longman, Toronto.
2. Leithold: The Calculus with Analytic Geometry, 3rd edition, Herper & Row, publishers.
3. Lynne, Garner: Calculus and Analytic Geometry, Dellen Publishing Company.
4. John A. Tierney: Calculus and Analytic, 4th edition, Allyn and Bacon, Inc. – Boston.
5. Earl W. Swokowski: Calculus with Analytic Geometry, 2nd edition, Prindle, Weber and Schmidt.

Course Title: **Linear Algebra I**
Course Code: **Math 325**
Credit Hours: **3**
Contact Hours: **Lecture 3 hrs per week , Tutorial 2 hrs per week**
Prerequisite:

Course Description
This course covers vectors; lines and planes; vector spaces; matrices; system of linear equations; determinants; eigenvalues and eigenvectors; linear transformations.

Course objectives
The main objective of this course is to lay down a foundation for advanced studies in linear algebra and related courses.

Leaning Outcomes
At the end of successful accomplishment of the course, students will be able to:

- understand the basic ideas of vector algebra,
- understand the concept of vector space over a field,
- understand the basic theory of matrix and its application,
- determine the eigegvalues and eigenvectors of a square matrix,
- grasp Gram-Schmidt process,
- find an orthogonal basis for a vector space,
- invert orthogonal matrix,
- understand the notion of a linear transformation,
- find the linear transformation with respect to two bases,
- find eigenvalues and eigenvectors of an operator.

Course outline

1. **Vectors (6 lecture hours)**
   1.1. Definition of points in n-space
   1.2. Vectors in n-space; geometric interpretation in 2-and3-spaces
   1.3. Scalar product and the norm of a vector, orthogonal projection, direction cosines
   1.4. The vector product
   1.5. Applications on area and volume
   1.6. Lines and planes
2. **Vector Spaces (10 lecture hours)**
   2.1. The axioms of a vector space
   2.2. Examples of different models of a vector space
   2.3. Subspaces, linear combinations and generators
   2.4. Linear dependence and independence of vectors
   2.5. Bases and dimension of a vector space
   2.6. Direct sum and direct product of subspaces

3. Matrices (12 lecture hours)

3.1. Definition of a matrix
3.2. Algebra pg matrices
3.3. Types of matrices: square, identity, scalar, diagonal, triangular, symmetric, and skew symmetric matrices
3.4. Elementary row and column operations
3.5. Row reduced echelon form of a matrix
3.6. Rank of a matrix elementary row/column operation
3.7. System of linear equations

4. Determinant (12 lecture hours)

4.1. Definition of a determinant
4.2. Properties of determent
4.3. Adjoint and inverse of a matrix
4.4. Generalized inverse
4.5. Cramer's rule for solving system of linear equations (homogenous and non homogenous)
4.6. The rank of matrix by subdeterminants
4.7. Determinant and volume
4.8. Eigenvalue and eigenvector of a matrix
4.9. Diagonalization of a symmetric matrix

5. Linear Transformations (8 lecture hours)

5.1. Linear transformations and examples
5.2. The rank and nullity of a definition of linear transformation and example
5.3. Algebra of linear transformations
5.4. Matrix representation of a linear transformation
5.5. Eigenvalues and eigenvectors of a linear transformation
5.6. Eigenspace of a linear transformation

Teaching and Learning Methods

Lecture, Tutorials and Assignments.

Textbooks

1. Lang; Linear Algebra
2. Demissu Gemeda, An Introduction to Linear Algebra

References

1. Hoffman and Kunze: Linear Algebra
2. Piage and swift: Linear Algebra
3. Beaumont: Linear Algebra
4. Halms: Finite Dimensional Vector space
5. Nomizu: Fundamentals of Linear Algebra
6. Anton H. and Rorres C. (2000). Elementary linear algebra: Application vision, 8th edn, John Wiley & Sons, Inc. , Canada.

Modes of Assessment

Assignment/quizzes	20%
Mid term exam	30%
Final examination	50%
Total	100%

Course Title: **Linear Algebra II**
Course Code: **Math 326**
Credit Hours: **3**
Contact Hours: **Lecture 3 hrs per week , Tutorial 2 hrs per week**
Prerequisite: **Math 325**

Course description
This course covers the characteristics equation of a matrix; orthogonality; matrix factorizations; canonical forms**;** direct sum decomposition of vector spaces; bilinear, quadratic and positive definite forms.

Course objective
This course intends to develop linear algebra providing a foundation for studies in a number of other areas of mathematics and related fields.

Learning Outcomes
At the end of successful accomplishment of the course, students will be able to:-

- Find the eigenvalues and eigenvectors of a square matrix,
- Identify similar matrices,
- Diagonalize a matrix when this is possible,
- Define inner product space,
- Find and apply the LU factorization of a matrix,
- Understand the Gram-Schmidt process,
- Find an orthogonal basis for a subspace,
- Find an orthogonal complement of a subspace,
- Recognize and invert orthogonal matrices,
- Comprehend the three canonical forms of matrices.

Course outline

1. Characteristic equation (9 lecture hours)
1.1 Eigenvalues and eigenvectors
1.2 The characteristic polynomial
1.3 Similarity of matrices and characteristic polynomial
1.4 The special radius of a matrix
1.5 Diagonalization
1.6 Decomposable matrices
1.7 Minimal polynomial and Cayley-Hamilton theorem

2. Orthognality (12 lecture hours)
2.1 The inner product
2.2 Inner product spaces
2.3 Orthonormal sets
2.4 The Gram-Schmidt orthogonalization process
2.5 Cauchy-Schwartz and triangular inequalities
2.6 The dual space

2.7 Adjoint of linear operators
2.8 Self-adjoint linear operators
2.9 Isometry
2.10 Normal operators and the Spectral theorem
2.11 Factorization of a matrix (LU, Cholesky, QR)
2.12 Singular Value Decomposition

3. Canonical forms (11 lecture hours)

3.1 Elementary row and column operations on matrices
3.2 Equivalence of matrices of polynomials
3.3 Smith canonical forms and invariant factors
3.4 Similarity of matrices and invariant factors
3.5 The rational canonical forms
3.6 Elementary divisors
3.7 The normal and Jordan canonical forms

4. Bilinear and Quadratic Forms (8 lecture hours)

4.1 Bilinear forms and matrices
4.2 Alternating bilinear forms
4.3 Symmetric bilinear forms; quadratic forms
4.4 Real symmetric bilinear forms

5. Direct Sum Decomposition of Vector Spaces (8 lecture hours)

5.1 Definition of a direct sum of vector spaces
5.2 Projection and invariant subspaces of a linear operator
5.3 Primary decomposition theorem

Teaching and Learning Methods

Lecture, Tutorials and Assignments.

Textbooks

1. Lang: Linear Algebra
2. Schaum's Outline in Linear Algebra

References

Anton H. and Rorres C. (2000). Elementary linear algebra: application vesion, 8 th, edn, John Wiley & Sons, Inc., Canada.

Modes of Assessment

Assignments / quizzes	20%
Mid-Semester Examination	30%
Final Examination	50%
Total	100%

Course title : **Calculus for Statistics**
Course code : **Math 335**
Credit hours : **3**
Contact hours: **Lecture 3 hrs per week , Tutorial 2 hrs per week**
Prerequisite : **Math 264**

Course Description

The course deals with indeterminate forms, improper integral and Taylor's formula; sequence and series of real numbers, power series; limit , continuity, differentiation of functions of several variables , application of partial derivatives and multiple integral.

Objective

This course intends to introduce students with the fundamental properties of indeterminate forms, sequences and series, and familiarize them with the theory and methods for differentiation and integration of functions of several variables.

Learning outcomes

At the end of successful completion of the course, the students will be able to:

- Determine convergence or divergence of a series,
- Find interval of convergence of a power series and find its sum in the interval,
- Find the Taylor's series expansion of a function
- approximate a function by using its power series,
- find the Taylor's series expansion of a function,
- Apply partial derivatives to physical problems,
- Evaluate multiple integrals of different functions of several variables.

Course Outline

1. Indeterminate forms, improper integrals and Taylor's formula (6 lecture hours)

1.1 Cauchy's formula
1.2 Indeterminate forms (L' Hopital's Rule)
1.3 Improper integrals

2. Sequence and series (12 lecture hours)

2.1 Sequences
2.1.1 Convergence and divergence of sequences
2.1.2 Properties of convergent sequences
2.1.3 Bounded and monotonic sequences

2.2 Infinite series
2.2.1 Definition of infinite series
2.2.2 Convergence and divergence of series
2.2.3 Properties of convergent series
2.2.4 Convergence tests for positive series (integral, comparison, ratio and root tests)
2.2.5 Alternating series
2.2.6 Absolute convergence, conditional convergence
2.2.7 Generalized convergent tests

2.3 Power series

2.3.1 Definition of power series
2.3.2 Convergence and divergence, radius and interval of convergence
2.3.3 Algebraic operation on convergent power series
2.3.4 Differentiation and integration of a power series
2.3.5 Taylor & Maclaurin series
2.3.6 Binomial Theorem

3. Partial differentiation (10 lecture hours)

3.1 Functions of several variables
3.2 Limits and continuity
3.3 Partial derivatives
3.4 The Chain rule

4. Application of partial derivatives (8 lecture hours)

4.1 Extreme values
4.2 Lagrange's multiplier
4.3 Taylor's theorem
4.4 The method of least squares
4.5 Differentiating integrals with parameters
4.6 Newton's method

5. Multiple integrals (12 lecture hours)

5.1 Double integrals
5.2 Double integrals in polar coordinates
5.3 Surface area
5.4 Triple integrals
5.5 Triple integrals in cylindrical coordinates
5.6 Change of variables in multiple integrals

Teaching and Learning Methods

Lecture, Tutorials and Assignments.

Modes of Assessment

Assignments / quizzes	20%
Mid-term examination	30%
Final Examination	50%
Total	100%

Textbook

Robert Ellis, Denny Gulick. Calculus with Analytic, 6th edition, Harcourt Brace Jovanovich, Publishers.

References

1 Adams R. A. (2003). Calculus: a complete course, 5 th, edn Addison, Wesley Longman, Toronto.

2 Howard Anton. Calculus (Multivariable) , 8th edition; John Wiley & Sons, Inc.

3 Robert T. Smith. Multivariable Calculus, 2nd edition; McGraw Hill.

4 Robert T. Seeley. Introduction to Calculus of several variables.

5 Staley I. Grossman. Calculus Part 2: Multivariable calculus, Linear algebra, and differential equations: Academic Press.

6 Goldstein, L. J., Lay D. C. , and Schneider D. I (1987). Calculus and its applications, 4th, edn, Prentice-Hall, Inc, London.

Course title: **Numerical Methods for Statistics**
Course code: **Math 339**
Credit hours: **3**
Contact Hours: **Lecture 3 hrs per week , Tutorial 2 hrs per week**
Prerequisite: **Math 264, Math 325**

Course description
This course covers basic concepts in error estimation solutions of non-linear equations, solutions of system of linear equations and non-linear equations, finite differences, numerical interpolations, numerical differentiation and integration, introductory first order initial value problems (IVP), Taylor's method and Euler's method.

Objective
The course intends to introduce students with finding numerical solutions to statistical problems for each analytical solution can easily be obtained. It also aims to help students develop programming skills.

At the end of accomplishment of the course, successful students will be able to:

- understand concepts of errors
- understand a range of iterative methods for solving linear and non-linear systems of equations
- understand the roles of finite differences
- understand the concept of IVP
- grasp the practical knowledge of interpolation in numerical solving of IVP
- develop skills in translating numerical algorithms into computer programming

Course Outline

1. Basic concepts in error estimation (4 lecture hours)
1.1 Sources of errors
1.2 Approximation of errors
1.3 Rounding off errors
1.4 Absolute and relative errors
1.5 Propagation of errors
1.6 Instability

2. Nonlinear Equations (9 lecture hours)
1.1 Locating Roots
1.2 Bisection Method
1.3 Interpolation and Secant methods
1.4 Iteration Method
1.5 Conditions for convergence
1.6 Newton Raphson's Method

3. **System of equations (10 lecture hours)**
3.1 Direct Methods for system of linear equations

3.1.1 Gauss's Method
3.1.2 Gauss's Method with Partial Pivoting
3.1.3 Jordan's Method
3.1.4 Matrix inversion using Jordan's Method
3.1.5 Matrix Decomposition
3.1.6 Tri Diagonal Matrix Method

3.2 Indirect Methods for system of linear equations
3.2.1 Gauss Jacobi Method
3.2.2 Gauss Seidel Method

3.3 Solving Systems of non-linear equations using Newton's method.

4. Finite differences (4 hours)

4.1 Shift operators
4.2 Forward difference operators
4.3 Backward difference operators

5. **Interpolation (6 lecture hours)**

5.1 Linear Interpolation
5.2 n^{th} degree Interpolation
5.3 Lagrange's Interpolation formula
5.4 Newton Interpolation Formula (forward and backward difference formulas)
5.5 Application of interpolation
5.5.1 Differentiation
5.5.2 Integration (Trapezoidal & Simpson's Rules)

6. First Order Initial Value Problems (9 lecture hours)

6.1 Definition of ODE and examples
6.2 Order of a differential equation, linear and nonlinear ODE
6.3 Nature of Solutions of ODE: particular and general solutions
6.4 Initial value problem
6.5 Existence of a unique solution (Picards theorem)
6.6 Method of separable of variables
6.7 Homogeneous equations
6.8 Exact equations, non-exact equations and integrating factor
6.9 Linear equations
6.10 Orthogonal trajectories

7. **Numerical Methods for Initial Value Problems (6 lecture hours)**

7.1 Taylor's method of order n
7.2 Euler's Method
7.3 Euler's modified method

Teaching and Learning Methods

Lecture, Tutorials and Computer lab.

Modes of Assessment

Computer lab assignment	20%
Mid-Semester Examination	30%
Final Examination	50%
Total	100%

Textbooks

1. Gerald C. F. and Wheatlly P. O., Applied numerical analysis 5th ed, Addison Wesley, Co.
2. Dennis G.Zill, A first course in Differential Equations

References

1. Richard L. Burden. (1981). Numerical Analysis, 2nd Ed.
2. P.A. Strock, Introduction to numerical analysis
3. Volkov (1986). Numerical methods
4. Frank Ayres (1981). Theory and Differential Equations, Schuam's outline series
5. Robert Ellis and Denny Glick, Calculus with Analytical Geometry- 3rd Ed.
6. Murray R. Spiegel, Advanced Calculus- Advanced Calculus for Engineering and Scientists.

10.3. General Education Courses

To be communicated.

15. Service Courses for other Departments

Course title: **Introduction to Statistics**
Course code: **Stat 270**
Credit hours: **3**
Contact Hours: **Lecture 3 hours per week, Tutorial 2 hours per week**
Pre-requisite:

Course description
Meaning of statistics; Methods of data collection; Methods of data presentation; Measures of location; Measures of variation; Moments, skewness and kurtosis; Counting Techniques; Concepts of Probability (classical approach); Probability distributions: Binomial, Poisson, Normal, t and Chi-square; Sampling and Sampling Distribution of the mean and proportion; Elementary description of the tools of statistical inference: Basic concepts; Estimation: (Point and Interval) for the population mean and proportion; Hypothesis testing on the population mean and proportion; Chi-square test of association. Each topic should begin with motivating examples.

Objectives
- to introduce students the basic statistical knowledge on data collection and presentation methods, Measures of Central Tendency and Variation, probability and probability distributions, one sample inference, regression and correlation;
- introduces the basic concepts of statistical thinking and reasoning;
- to enable students apply the methods of statistics in scientific research, decision making and future career;
- to demonstrate the importance and practical usefulness of probability in real life;
- to show how probability is a necessary foundation for understanding statistics;
- to demonstrate the importance and usefulness of statistics in real life and on real data;
- to show how to present data informatively and clearly;
- to equip students to apply probability and statistical methods to solve standard problems from a wide range of disciplines;
- to give students an appreciation of the limitations of these standard techniques;
- to enable students to communicate the results of their analyses in clear non-technical language;

Learning outcomes
At the end of the course students are expected to:
- have a broad knowledge of the basic understanding of statistical techniques demonstrated through principles of data collection, descriptive statistics, probability, probability and sampling distributions, statistical inference and linear regression.
- understand the methods of data collection, organization, presentation, analysis and interpretation;

- know what is meant by sample space, event, relative frequency, probability, conditional probability, independence, random variable, probability distribution, probability density function, expected value and variance;
- be familiar with some standard discrete and continuous probability distributions;
- be able to use standard statistical tables for the Normal t, chi-square distributions;
- be able to differentiate between common types of data, and display them appropriately;
- learn some desirable properties of point estimators;
- recognize the additional benefits of calculating interval estimates for unknown parameters;
- understand the framework of hypothesis testing for carrying out statistical inference;
- be able to produce and interpret interval estimates and tests of hypotheses correctly in some simple cases;
- be able to present their results correctly and in non-technical language;
- have basic skills in exploratory data analysis.

Course Outline

1. **Introduction (3 lecture hours)**
   1.1 Definition and classification of Statistics
   1.2 Stages in statistical investigation
   1.3 Definition of Some Basic terms
   1.4 Applications, uses and limitations of Statistics
   1.5 Types of variables and measurement scales
2. **Methods of Data Collection and Presentation (4 lecture hours)**
   2.1 Methods of data collection
      2.1.1 Sources of data
      2.1.2 Methods of collection
   2.2 Methods of Data Presentation
      2.2.1 Motivating examples
      2.2.2 Frequency Distributions: qualitative, quantitative: absolute, relative and Percentage.
      2.2.3 Tabular presentation of data
      2.2.4 Diagrammatic presentation of data: Bar charts, Pie-chart, Cartograms
      2.2.5 Graphical presentation of data: Histogram, and Frequency Polygon
3. **Measures of Central Tendency (5 lecture hours)**
   3.1 Motivating example
   3.2 Objectives of measures of central tendency
   3.3 Summation notation
   3.4 Important Characteristics of a good average
   3.5 Mean
      3.4.1 Arithmetic Mean
      3.4.2 Geometric Mean
      3.4.3 Harmonic Mean
   3.6 Median

3.7 Mode

4. **Measures of variation (Dispersion), Skewness and Kurtosis (5 lecture hours)**
   - 4.1 Motivating examples
   - 4.2 Objectives of measures of central tendency
   - 4.3 Measures of Dispersion (Variation)
     - 4.3.1 Range
     - 4.3.2 Variance, Standard Deviation and coefficient of variation
     - 4.3.3 Standard scores
   - 4.4 Moments
   - 4.5 Skewness
   - 4.6 Kurtosis

5. **Elementary Probability (5 lecture hours)**
   - 5.1 Introduction
   - 5.2 Definition & some concepts (Experiment, sample, event, equally likely outcomes, mutually exclusive events, independent events)
   - 5.3 Random experiments
   - 5.4 Counting rules: addition, multiplication rules, permutation and combination
   - 5.5 Definitions of probability (probability of an event)
   - 5.6 Some rules of probability

6. **Probability Distributions (7 lecture hours)**
   - 6.1 Definition of random variables (discrete and continuous) and probability distributions
   - 6.2 Introduction to expectation: mean and variance of random variable
   - 6.3 Common discrete distributions: binomial and Poisson
   - 6.4 Common continuous distributions: Normal, t, and chi-square distribution

7. **Sampling and Sampling Distributions of the Mean (3 lecture hours)**
   - 7.1 Basic concepts (population, sample, parameter, statistic, sampling frame, Sampling unit, sampling error, sample size)
   - 7.2 Reasons for Sampling
   - 7.3 Different types of Sampling (Probability vs Non probability Sampling Techniques)
   - 7.4 Simple random sampling (lottery method, table or computer generated random numbers)
   - 7.5 Sampling distribution of the sample mean and proportion
   - 7.6 Central limit theorem

8. **Estimation and Hypothesis Testing (10 lecture hours)**
   - 8.1 Estimation
     - 8.1.1 Motivating examples
     - 8.1.2 Point estimation: mean and proportion
     - 8.1.3 Interval estimation: mean and proportion
   - 8.2 Hypothesis Testing
     - 8.2.1 Motivating examples
     - 8.2.2 Important concepts in testing a statistical hypothesis
     - 8.2.3 Steps in testing a hypothesis
     - 8.2.4 Hypothesis testing about the population mean

8.2.5 Hypothesis testing about the population proportion
8.2.6 Chi-square test of association

9. Simple Linear Regression and Correlation (6 lecture hours)

9.1 Motivating examples
9.2 Introduction: regression and correlation
9.3 Simple Linear Regression
9.4 Correlation Coefficient

Textbook

Bluman, A.G. (1995). Elementary Statistics: A Step by Step Approach (2nd edition). Wm. C. Brown Communications, Inc.

References

1. Coolidge, F.L.(2006). Statistics: A Gentle Introduction (2nd edition).
2. David, S.M., McCabe, P. and Craig, B. (2008). Introduction to the Practice of Statistics (6th edition). W.H. Freeman.
3. Eshetu Wencheko (2000). Introduction to Statistics. Addis Ababa University Press.
4. Freund, J.E and Simon, G.A. (1998). Modern Elementary Statistics (9th Edition).
5. Gupta, C.B. and Gupta, V. (2004). An Introduction to Statistical Methods. Vikas Publishing House, Pvt. Ltd, India.
6. Snedecor, G.W and Cochran, W.G. (1980). Statistical Methods (7th edition).
7. Spiegel, M.R. and Stephens, L.J. (2007). Schaum's Outline of Statistics, Schaum's Outline Series (4th edition). McGraw-Hill.
8. Woodbury, G. (2001). Introduction to Statistics. Duxbury press.

Teaching and learning methods

Lectures, tutorials, discussions, demonstration and assignments.

Modes of Assessment

Two or more tests and assignments	20%
Mid Semester Examination	30%
Final Examination	50%
Total	100%

Course title: **Introductory Probability**
Course code: **Stat 276**
Credit hours: **3**
Contact Hours: **Lecture 3 hours per week, Tutorial 2 hours per week**
Pre-requisite:

Course description
Review of elementary probability; Random variables; Probability distributions; Common Discrete Probability Distributions: Binomial, Poisson, Geometric and Hypergeometric; Common Continuous Distributions: Uniform, Normal, exponential, t, chi-square, and F; Two-dimensional random variables, Definition of distribution functions, Marginal distributions, Conditional distributions, Expectation, Covariance and Correlation.

Objectives
- to introduce students to fundamental concepts in probability theory;
- to introduce the basic principles and methods of quantification of uncertainty;
- to introduce the basics of random variables, common probability distributions and expectation;
- to introduce two dimensional random variables their probability distributions including marginal and conditional distributions and independence;
- to introduce one and two dimensional functions and computing their probability distribution, expectation, variance and correlation;
- to demonstrate the importance and usefulness of probability in real applications.

Learning outcomes
At the end of the course students are expected to:
- have equipped with basic concept of probability and a good appreciation of the laws of probability;
- know what is meant by random variable, probability distribution, cumulative distribution function, probability density function, expectation, variance and correlation;
- have the skills to tackle simple problems on probability distributions;
- understand conditional probability and independence;
- know what is meant by joint, marginal and conditional distribution and independent random variables;
- be familiar with one and two dimensional random variables and their functions and deriving their probability distributions and computing their expectation, variance and correlation;
- be familiar with standard discrete and continuous probability distributions, how they arise in practice and their elementary properties.

Course Outline

1. **Review (2 lecture hours)**
   1.1 Deterministic and non-deterministic models

1.2 Random experiments, sample space and events
1.3 Review of set theory: sets, union, intersection, complementation, De Morgan's rules
1.4 Finite sample spaces
1.5 Equally likely outcomes
1.6 Counting techniques
1.7 Axioms of probability
1.8 Derived theorems of probability

2. Conditional Probability and Independence (3 lecture hours)

2.1. Conditional Probability
2.2 Multiplication rule
2.4 Partition Theorem, Bayes' Theorem and Applications
2.5 Independent Events

3. One-dimensional Random Variables (3 lecture hours)

3.1 Random variable: definition and distribution function
3.2 Discrete random variables
3.3 Continuous random variables
7.7 Cumulative distribution function and its properties

4. Functions of Random Variables (6 lecture hours)

4.1 Equivalent events
4.2 Functions of discrete random variables and their distributions
4.3 Functions of continuous random variables and their distributions

5. Two-Dimensional Random Variables (8 lecture hours)

5.1 Two-dimensional random variables
5.2 Joint distributions for discrete and continuous random variables
5.3 Marginal and conditional probability distributions
5.4 Independent random variables
5.5 Distributions of functions of two random variables

6. Expectation (5 lecture hours)

7.2 Expectation of random variable
7.3 Expectation of a function of a random variable
7.4 Properties of expectation
7.5 Variance of a random variable and its Properties
7.6 Chebyshev's Inequality
7.7 Covariance and Correlation Coefficient
7.8 Conditional Expectation

7. Common Discrete Distributions and their Properties (10 lecture hours)

7.1 Binomial distribution
7.2 Poison distribution
7.3 Hypergeometric distribution
7.4 Geometric distribution
7.5 Multinomial distribution

8. Common Continuous Distributions and their Properties (11 lecture hours)

1.1 Uniform distribution
1.2 Normal distribution

1.3 Exponential distribution
1.4 Chi - square distribution
1.5 t distribution
1.6 F distribution
1.7 Bivariate normal distribution

Textbook

Ross S. (2006). A First Course in Probability (7th Edition). Prentice-Hall, Upper Saddle Rivel, New Jersey.

References

1. Cheaffer, R.L. and McClave, J.T (1994). Probability and Statistics for Engineers (4nd Edition). Duxbury Press.
2. Lipschutz, S. and Schiller, J. (1998). Introduction to Probability and Statistics. Schaum's Outline Series, Mc Graw-Hill.
3. Mendenhall, W., Beaver, R.J. and Bearer, B.M. (2008). Introduction to Probability and Statistics (13th Edition). Duxbury Press.
4. Mendenhall, W., Beaver, R.J. and Bearer, B.M. (2005). Student Solutions Manual for Introduction to Probability and Statistics (12th Edition). Duxbury Press.
5. Walpole, R. E., Myers, S.L. and Ye, K. (2006). Probability and Statistics for Engineers and Scientists (6th Edition). Prentice Hall.
6. Roussas, G. G. (2006). Introduction to Probability. Academic Press.
7. Bertsekas, D. P. and Tsitsiklis, J. N. (2008). Introduction to Probability (2nd Edition). Athena Scientific.
8. Suhov, Y. and Kelbert, M. (2005). Probability and Statistics by Examples. Cambridge University Press.

Teaching and learning methods

Lectures, tutorials and assignments.

Mode of Assessment and Evaluation

Two or more tests and assignments	20%
Mid-Semester Examination	30%
Final Examination	50%
Total	100%

Course title: **Statistics for Geologists**
Course code: **Stat 280**
Credit hours: **3**
Contact hours: **Lecture 3 hours per week, Tutorial 2 hours per week**
Pre-requisite:

Course description
Definition and classification of statistics; Methods of collecting geological data; Summarizing geological data using descriptive statistics**;** Counting techniques; Concepts of Probability (classical approach); Probability distributions: Binomial , Poisson ,Normal, Log-normal, Exponential , Gamma, t, F and chi-square ; Sampling and sampling distribution; Statistical Inference: Basic concepts; Estimation: (Point and Interval) for the population mean; Hypothesis testing on the population mean; Comparison of two sample means; Introduction to experimental design and analysis: basic concepts, One way ANOVA and Multiple comparisions; Regression and correlation: simple linear regression and correlation; rank correlation; multiple regression. Each topic should begin with motivating examples**.** Emphasis on application to geological problems.

Objectives
- to introduce students to statistical methods appropriate for the analysis of geological data;
- to enable students apply the methods of statistics in scientific research, decision making and future career;
- to demonstrate the importance and practical usefulness of statistics and probability in geological problems;
- to show how probability is a necessary foundation for understanding statistics;
- to show how to present data informatively and clearly;
- to equip students to apply probability and statistical methods to solve standard problems from a wide range of disciplines;
- to give students an appreciation of the limitations of standard statistical methods;
- to enable students to communicate the results of their analyses in clear non-technical language.

Learning outcomes
At the end of the course students are expected to:
- have a broad knowledge of the basic understanding of statistical techniques in geological problems demonstrated through principles of data collection, descriptive statistics, probability, probability and sampling distributions, statistical inference, design and analysis of experiments, regression and correlation.
- understand the methods of data collection, organization, presentation, analysis and interpretation in geological studies;
- know what is meant by sample space, event, relative frequency, probability, conditional probability, independence, random variable, probability distribution, probability density function, expected value and variance;
- be familiar with some standard discrete and continuous probability distributions used in geological problems;

- be able to use standard statistical tables for the Normal t, F and chi-square distributions;
- be able to differentiate between different types of geological data, and display them appropriately;
- understand the framework of hypothesis testing for carrying out statistical inference;
- recognize the additional benefits of calculating interval estimates for unknown parameters;
- be able to produce and interpret interval estimates and tests of hypotheses correctly in some simple cases;
- understand linear and nonlinear regression modeling, correlation and analysis of variance;
- be able to present their results correctly and in non-technical language;
- have basic skills in exploratory data analysis.

Course Outline

1. **Introduction (3 lecture hours)**
   - 1.1 Definition and classification of Statistics
   - 1.2 Stages in statistical investigation
   - 1.3 Definition of Some Basic terms
   - 1.4 Applications, uses and limitations of Statistics
   - 1.5 Types of variables and measurement scales
   - 1.6 Types of geological data
   - 1.7 Methods of collecting geological data
2. **Summarizing Geological Data (6 lecture hours)**
   - 2.1 Motivating examples
   - 2,2 presentation of Data: frequency distribution, tables, diagrams and graphs
   - 2.3 Central Tendency
     - 2.3.1 Objectives
     - 2.3.2 Arithmetic Mean
     - 2.3.3 Median and Mode
     - 2.3.4 Weighted Mean
   - 2.4 Dispersion/Variation
     - 2.4.1 Objectives
     - 2.4.2 Range
     - 2.4.3 Standard deviation, variance and standard score
   - 2.5 Mean and variance of spatially distributed samples: Kriging
   - 2.6 Mean and variance for circular data
3. **Elementary Probability (5 lecture hours)**
   - 3.1 Introduction
   - 3.2 Definition & some concepts (Experiment, sample, event, equally likely outcomes, mutually exclusive events, independent events)
   - 3.3 Random experiments
   - 3.4 Counting rules: addition, multiplication rules, permutation and combination
   - 3.5 Definitions of probability

3.6 Some rules of probability
3.7 Conditional Probability

4. **Random Variables and Common Probability Distributions in Geological Applications (7 lecture hours)**
   4.1 Random variable: definition, type and probability distribution
   4.2 Expectation: mean and variance of random variable
   4.3 Discrete distributions: binomial, geometric and Poisson
   4.4 Continuous distributions: normal, log-normal, exponential, gamma, t, F and chi-square
   4.5 Comparing frequency distribution curves with the normal distribution: probability plot; logarithmic and other transformations
5. **Sampling and sampling distribution (3 lecture hours)**
   5.1 Basic concepts (population, sample, parameter, statistic, sampling frame, Sampling unit, sampling error, sample size)
   5.2 Reasons for Sampling
   5.3 Different types of Sampling (Probability vs Non probability Sampling Techniques)
   5.4 Simple random sampling (lottery method, table or computer generated random numbers), systematic and stratified samplings
   5.5 Spatial Sampling
   5.6 Sampling distribution of the sample mean
6. **Estimation and Hypothesis Testing (10 lecture hours)**
   6.1 Estimation
      6.1.1 Motivating examples
      6.1.2 Point estimation of the mean
      6.1.3 Interval estimation of the mean
   6.2 Hypothesis Testing
      6.2.1 Motivating examples
      6.2.2 Important concepts in testing a statistical hypothesis
      6.2.3 Steps in testing a hypothesis
      6.2.4 Hypothesis testing about the mean
      6.2.5 Comparing two means (independent and paired samples)
      6.2.6 Non-parametric tests: sign and rank tests
      6.2.7 Chi-square test for contingency table
7. **Introduction to Statistical Design and Analysis of Geological Experiments (5 lecture hours)**
   7.1 Introduction: randomization, replication, treatments and completely randomized design
   7.2 One-way ANOVA for comparing more than two means
   7.3 Multiple comparison tests
8. **Regression and Correlation (9 lecture hours)**
   8.1 Motivating examples
   8.2 Introduction: regression and correlation
   8.3 Fitting simple linear regression
   8.4 Correlation Coefficient

8.5 Rank correlation
8.6 Curve fitting: quadratic, logarithmic, exponential and cubic
8.7 Multiple linear regression

Textbooks

1. Davis, J. C. (2002). Statistics and Data Analysis in Geology (3rd edition). Wiley, New York.
2. Blaesid, P. and Granfeldt, J. (2002). Statistics with Applications in Biology and Geology. Chapman and Hall, CRC.

References

1. Bluman, A.G.. Elementary Statistics: A Step by Step Approach.
2. Coolidge, F.L.(2006). Statistics: A Gentle Introduction (2nd edition).
3. David, S.M., McCabe, P. and Craig, B. (2008). Introduction to the Practice of Statistics (6th edition). W.H. Freeman.
4. Eshetu Wencheko (2000). Introduction to Statistics. Addis Ababa University Press.
5. Freund, J.E and Simon, G.A. Modern Elementary Statistics (9th Edition).
6. Gupta, C.P. Introduction to Statistical Methods (9th Revised Edition).
7. Snedecor, G.W and Cochran, W.G. (1980). Statistical Methods (7th edition).
8. Spiegel, M.R. and Stephens, L.J. (2007). Schaum's Outline of Statistics, Schaum's Outline Series (4th edition). McGraw-Hill.
9. Woodbury, G. (2001). Introduction to Statistics. Duxbury press.

Teaching and learning methods

Lectures, tutorials, discussions, demonstration, computer lab practicals and assignments.

Modes of Assessment

Two or more tests and assignments	20%
Mid Semester Examination	30%
Final Examination	50%
Total	100%

Course Title: **Fundamentals of Biostatistics**
Course Code: **Stat 281**
Credit hour: 3
Contact hours: **Lecture 3 hours per week, Tutorial 2 hours per week**
Course Category:
Prerequisite course: **None**

Course Rationale

Without usage of statistical knowledge it might not be possible to analyze research data. Thus, the course is given for biologists to assist them analyze and interpret biological research findings. Students will be equipped with knowledge on selection of appropriate statistical tools to describe, organize, interpret and present biological data.

Objectives
At the end of this course, the student will be able to:

- Explain basics of research design and statistical analysis.
- Apply the basic concepts of biostatistics.
- Describe different sampling techniques used in data collection.
- Use different statistical methods to analyze biological data.

Course Description

The course deals with the basic concepts of biostatistics; sampling theory; methods of data collection and presentation; different tables and their biological usage; data presentation in graphs in biology; measurement of central tendency and their use in biological data analysis; measures of dispersion as applied to biology; theories and applications of probability; different probability distributions and their use for decision making in biological experiments; Hypothesis testing in biological data analysis (chi-square test, simple linear regression and correlation); Analysis of Variance (ANOVA) and its application in biological experiment design.

Course content:

1. **Introduction (4 lecture hours)**
   1.1. Definitions and classification of statistics
   1.2 Stages in statistical investigation
   1.3. Definition of some terms
   1.4. Applications, uses and limitations of statistics
   1.5. Scales of measurement
   1.6. Introduction to methods of data collection
2. **Methods of data presentation (4 lecture hours)**
   2.1 Frequency distributions: Qualitative, quantitative (absolute, relative, percentage, cumulative)
   2.2. Diagrammatic and graphical presentation of data (bar charts, pie-chart, histogram, frequency polygon, ogive curve)

3. Measures of central tendency (6 lecture hours)

3.1. Introduction and objectives of measuring central tendency
3.2. The summation notation
3.3. Properties of measures of central tendency
3.4. Types of measures of central tendency
3.4.1. The arithmetic mean (simple and weighted)
3.4.2. The geometric mean
3.4.3. The harmonic mean
3.4.4. The mode
3.4.5. The median and other quantiles (quartiles, deciles, percentiles)

4. Measures of variation (dispersion) (6 lecture hours)

4.1 Introduction and objectives of measuring variation
4.2 Absolute and relative measures
4.3 Types of measures of variation
4.3.1. The range and relative range
4.3.2. The quartile deviation and coefficient of quartile deviation
4.3.3. The mean deviation and coefficient of mean deviation
4.3.4. The variance, the standard deviation and the coefficient of variation
4.3.5. The standard scores
4.4. Moments (about the origin and about the mean), skewness and kurtosis

5. Elementary probability (4 lecture hours)

5.1. Introduction
5.2. Definition of some probability terms
5.3. Counting rules: addition and multiplication rules, permutation and combination
5.4. Probability of an event
5.5. Some probability rules
5.6. Conditional probability and independence

6. Probability distributions (4 lecture hours)

6.1. Definition of random variables and probability distributions
6.2. Introduction to expectation – mean and variance of a random variable
6.3. Common discrete probability distributions – binomial and Poisson
6.4. Common continuous probability distributions - normal, chi-square and *t* and F distributions

7. Sampling and sampling distribution of the mean (6 lecture hours)

7.1. Methods of sampling (simple random sampling :the lottery method, table of random numbers)
7.2. Sampling distribution of the sample mean
7.3. Sampling distribution of the sample proportion
7.4. Standard errors
7.5. The central limit theorem

8. Estimation and hypothesis testing (6 lecture hours)

8.1. Point and interval estimation of the mean
8.2. Point and interval estimation of the proportion
8.3. Sample size determination
8.4. Hypothesis testing about the mean

8.5. Hypothesis testing about the proportion
8.6. Tests of association

9. Two samples inference (4 lecture hours)

9.1. Inferences about differences between means
9.2. Inferences about differences between proportions
9.3. Inferences concerning variances

10. Simple Linear Regressions and Correlation (4 lecture hours)

10.1. Simple linear regression (regression of Y on X)
10.2. The covariance and the correlation coefficient
10.3. The rank correlation coefficient

Modes of Assessment

Two or more tests and assignments	20%
Mid Semester Examination	30%
Final Examination	50%
Total	100%

Textbook

Rastogi, V. B. (2006). Fundamentals of Biostatics. Ane Books India, New Delhi.

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1. Bluman, A.G. (1995). Elementary Statistics: A Step by Step Approach (2nd edition). Wm. C. Brown Communications, Inc.
2. Eshetu Wencheko (2000). Introduction to Statistics. Addis Ababa University Press.
3. Freund, J. E. and Simon, G. A. (1998). Modern Elementary Statistics.
4. Spiegel, M. R. (2001). Theory and Problem of Statistics. Schaums Outline Series.