Course Content - Department of Statistics

ST 1006	Introduction to Probability and Statistics	MS 3009	Operational Research II
ST 1008	Probability and Distributions	IS 3003	Special Topics I
ST 1009	Exploratory Data Analysis	IS 3052	Advanced Topics in Experimental Design
ST 1010	Statistical Theory	IS 3053	Data Mining Techniques
ST 1011	Introduction to Surveys	MS 3004	Quality Management/Project Management
IS 1006	Fundamentals of Statistics	MS 3008	Accounting for Finance
IS 1007	Introduction to Statistical computing	ST 3008	Applied Statistical Models
MS 1001	Principles of Management	ST 3009	Applied Time Series
IS 1008	Introduction to Probability and Distributions	ST 3010	Introduction to Health Statistics
IS 1009	Introduction to Survey Design	ST 3011	Statistical Programming
MS 1003	Operational Research I	IS 3004	Applied Multivariate Methods
ST 2006	Basic Statistical Inference	IS 3005	Statistics in Practice I
ST 2007	Applications in Statistical Inference	ST 4051	Scientific Writing
ST 2008	Statistical Methods in Quality Control	ST 4054	Linear Models
ST 2004	Analysis of Variance and Design of Experiments	ST 4011	Econometrics
ST 2009	Applied Non-Parametric Methods	ST 4031	Stochastic Processes and Application
ST 2010	Introduction to Statistical Modeling	ST 4052	Statistical Learning II
IS 2005	Statistical Packages	ST 4056	Medical Statistics
MS 2001	Statistical Quality Control	ST 4012	Special Topics for ST
IS 2003	Design and Analysis of Industrial Experiments	ST 4013	Special Topics for ST+CS
MS 2004	Introduction to Marketing Research	ST 4055	Generalized Linear Models
ST 3003	Marketing Research	ST 4040	Individual Project ST+CS
ST 3007	Operational Research	ST 4050	Individual Project ST
ST 3051	Statistical Inference I	EC 4004	Industrial Training
ST 3072	Applied Regression Analysis	IS 4002	Advanced Statistical Modeling
ST 3085	Computational Statistics	ST 4035	Data Science
ST 3074	Time Series Analysis	IS 4003	Special Topics II
ST 3075	Design of Experiments	MS 4007	Risk Management
ST 3076	Reliability Data Analysis	MS 4008	Industrial Psychology
ST 3012	Statistical Process Control	IS 4005	Industrial Training
ST 3070	Special Topics	IS 4006	Individual Project
ST 3083	Multivariate Data analysis	ST 4036	Time to Event Analysis
ST 3084	Statistical Inference II	ST 4037	Epidemiology
ST 3073	Survey and Sampling	IS 4007	Statistics in Practice II
ST 3082	Statistical Learning I	IS 4009	Industrial Training
ST 3013	Essential Mathematics for Statistics	IS 4010	Industrial Research Project
IS 3001	Sampling Techniques		
IS 3050	Statistical Inference		
IS 3051	Advanced Statistical Process Control		
ST 3006	Regression Analysis		
MS 3002	Advanced Marketing Research		

Courses offered by the Department of Statistics for Level I and II

Physical Science

Level One

	Pre Req	Course Unit	Title	Credit	Hours	P1	P2	P3	P4	P5	P6
SI		ST 1006	Introduction to Probability and Statistics	2	30L	x		x		x	
SI		ST 1008	Probability and Distributions	2	30L		x		x		x
SI		ST 1009	Exploratory Data Analysis	2	15L30P		x		x		x
SII		ST 1010	Statistical Theory	2	30L		x		x		x
SII		ST 1011	Introduction to Surveys	2	15L30P	o	o	o	o	o	o
SII		ST 1012	Basic Statistical Computing	2	15L30P	o	o	o	o	o	o

Level Two

	Pre Req	Course Unit	Title	Credit	Hours	P1	P2	P3	P4	P5	P6
SI		ST 2006	Basic Statistical Inference	3	45L	o	x	o	x	o	x
SI		ST 2007	Applications in Statistical Inference	1	30P		x		x		x
SI		ST 2008	Statistical Methods in Quality Control	2	30L	o	o	o	o	o	o
SII	ST2006	ST 2004	Analysis of Variance and Design of Experiments	2	30L	o	x	o	x	o	x
SII	ST 2006	ST 2009	Applied Non Parametric Methods	2	30L	o	o	o	o	o	o
SII		ST 2010	Introduction to Statistical Modeling	1	15L		o		o		o

Course Content - Level I

Course title: Introduction to Probability and Statistics (2C, 30L)

Course code: ST 1006

Rationale: The theory and methods of probability and statistics play an important role in our lives. They enable important understanding to be gained and informed decisions to be made, about a population by examining only a small random sample from that population. The course is designed to develop students' understanding and knowledge of descriptive and inferential statistics, and to strengthen students' skills in data analysis and interpretations.

Prerequisites: None

Intended learning outcomes:
Upon successful completion of the course the student should be able to describe data graphically and compute summary measures, compute probabilities by modeling sample spaces and apply rules of probability, construct the probability distribution of a random variable, expectation and variance, identify and compute probabilities based on practical situations using commonly used distributions.

Course content:
Descriptive Statistics: Types of data (qualitative, quantitative, continuous, discrete, etc.); scales of measurement (nominal, ordinal, interval, ratio); data summarization: frequency table, cum. frequency table, histogram, bar chart, pie chart, percentiles, quartiles, 5–number summary, Box plot, outliers; Measures of location: mean, trimmed mean, median, mode; Measures of dispersion: range, inter quartile range, variance, standard deviation, coefficient of variation; skewness, kurtosis; Counting techniques: counting rules, permutations and combinations; Elementary probability: probability definitions, finite sample space, events, probability rules and associated theorems, conditional probability, independence, multiplication rule, Bayes' theorem; One dimensional random variables: probability density function and probability (mass) function, cum. distribution function, expected value and variance of functions of random variables, moment generating function; Probability distributions: discrete distributions (Uniform, Bernoulli, Binomial, Poisson) and applications; continuous distributions (Uniform, Exponential, Normal) and applications; central limit theorem with applications.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%) [2 in-class assignments]

Suggested Readings:

- Mann, P. S. (2010). *Introductory Statistics* (7th ed). John Wiley & Sons.
- Crawshaw, J., & Chambers, J. (1984). *A Concise Course in A-Level Statistics* (4th ed). Nelson Thornes Limited.
- Wackerly, D. D., Mendenhall, W., & Scheaffer, R. L. (2008). *Mathematical Statistics with Applications* (7th ed). Cengage Learning
- Anderson, D. R., Sweeney, D. J., & Williams, T. A. (2011). *Statistics for Business and Economics* (11th ed.). South-Western College
- Spiegel, M. R., Schiller, J.J, & Srinivasan, R.A. (2012). *Schaum's Outline of Probability and Statistics* (4th ed). McGraw-Hill Education

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Course title: Probability and Distributions (2C, 30L)

Course code: ST 1008

Rationale: The measure of how likely an event is to happen is termed as probability. A mathematical function that provides the probability of occurrence of various possible outcomes of an experiment is termed as probability distribution. The subject is basically concerned with the concepts of probability and probability distributions based on different types of random variables.

Prerequisites: None

Intended learning outcomes: Upon successful completion of the course the student should be able to compute probabilities by modeling sample spaces and apply rules of probability, construct the probability distribution of a random variable, expectation and variance, identify and compute probabilities based on practical situations using commonly used distributions, and the central limit theorem.

Course content:
Introduction to probability; Counting techniques: counting rules, permutations and combinations; Elementary probability: probability definitions, finite sample space, events, probability rules and associated theorems, conditional probability, independence, multiplication rule, Bayes' theorem; One dimensional random variables: probability density function and probability (mass) function, cum. distribution function, expected value and variance of functions of random variables, moment generating function; Probability distributions: discrete distributions (Uniform, Bernoulli, Binomial, Negative Binomial, Hypergeometric, Poisson, and Geometric) and applications; continuous distributions (Uniform, Exponential, Gamma, Chi-squared, Beta, Normal, t and F) and applications; central limit theorem with applications.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%)[2 in-class assignments]

Suggested Readings:

- Mann, P. S. (2010). *Introductory Statistics* (7th ed). John Wiley & Sons.
- Wackerly, D. D., Mendenhall, W., & Scheaffer, R. L. (2008). *Mathematical Statistics with Applications* (7th ed). Cengage Learning
- Spiegel, M. R., Schiller, J.J, & Srinivasan, R.A. (2012). *Schaum's Outline of Probability and Statistics* (4th ed). McGraw-Hill Education

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Course title: Exploratory Data Analysis (2C, 15L 30P)

Course code: ST 1009

Rationale: Exploring Data is essential to understand the structure and pattern of the data. This course trains the students to explore data sets of various types and teaches suitable methods to organize and present data to extract stories from them.

Prerequisites: None

Intended learning outcomes:

Upon successful completion of the course the student should be able to explore and interpret data and draw meaningful conclusions using descriptive methods using one or more statistical software packages. The students should be able to clearly present statistical information, in both written and oral form.

Course content:
Picturing distributions with graphs: Individuals and variables, Categorical variables (pie charts, bar graphs), Quantitative variables (histograms, stemplots, time plots), picturing distributions with graphs using statistical software; Describing distributions with numbers: measuring center (mean, median, comparing the mean and the median), measuring spread (quartiles, five-number summary, boxplots, spotting suspected outliers, standard deviation), choosing measures of center and spread, describing distributions with numbers using statistical software; organizing a statistical problem; The Normal distributions: density curve, the 68–95–99.7 rule, the standard Normal distribution, finding Normal proportions; Relationships between two quantitative variables: explanatory and response variables, scatterplots, adding categorical variables to scatterplots, measuring linear association-correlation, facts about correlation, the best fitted line using least-squares, misuses of correlation and least square relationships; Relationship between two categorical variables: marginal distributions, conditional distributions, Simpson's paradox; General Misuses of Statistics

Teaching/ Learning Methods: Lectures, practical sessions and group activities

Method/s of evaluation: End of semester examination (50%) and Continuous assessments [At least 3 in class assignments and 1 group project](50%)

Suggested Readings:

- Moore, D. S., Notz, W. I., & Fligner M. A. (2011). *The Basic Practice of Statistics (6th ed).* W. H. Freeman

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Course title: Statistical Theory (2C, 30L)

Course code: ST 1010

Rationale: This course explains how to use statistical theories in problems in the real world. Random variables, many statistical distributions and their properties will be discussed. Multidimensional random variables and transformation techniques are also being discussed. Apart from that, theories of order statistics will be discussed.

Prerequisites: ST 1008 - Probability and Distributions

Intended learning outcomes:
Upon completion of this course, students should be able to integrateadvanced concepts in probability and efficiently apply them for problem solving.

Course content:
Two–dimensional random variables: joint distribution (discrete, continuous), marginal and conditional distributions, independence, bivariate normal distribution, covariance, correlation, conditional expectation, expectation of functions of random variables; Bivariate transformations (discrete and continuous); Order statistics; Asymptotic theory.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%)[2 in-class assignments]

Suggested Readings:

- Gupta, S. C., & Kapoor, V. K. (2000). *Fundamentals of Mathematical Statistics* (10th ed). Sultan Chand & Sons
- Wackerly, D. D., Mendenhall, W., & Scheaffer, R. L. (2008). *Mathematical Statistics with Applications* (7th ed). Cengage Learning
- David, H. A., & Nagaraja, H. N. (2003). *Order Statistics* (3rd ed). John Wiley and Sons.
- Serfling, R. J. (1980) *Approximation Theorems of Mathematical Statistics* (1st ed). Wiley Interscience

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Course title: Introduction to Surveys (2C,15L 30P)

Course code: ST 1011

Rationale: It is often required to conduct surveys to obtain information about individuals. A survey should be carefully planned and conducted to obtain the right information. Slight mistake may lead to obtain completely wrong information. [ST1011 provides the foundation knowledge to conduct a survey with practical experience]

Prerequisites: None

Intended learning outcomes:
Upon successful completion of the course the student should be able to solve a real life problem by properly planning and designing a survey focusing on selecting a sample scientifically.

Course content:
Producing data via surveys: Random & nonrandom sampling methods, cautions about sample surveys, planning and designing surveys, designing a questionnaire, pretesting, margin of error; Producing data via experiments: Randomized experimental methods, cautions about experiments; Solving a real world problem through a sample survey: Formulate a suitable research question, develop an appropriate sampling scheme, develop questionnaire, develop implementation plan, data collection, and analysis.

Teaching/ Learning Methods: Interactive lectures and group activities

Method/s of evaluation:
End of semester examination (40%) and Continuous assessment [At least 2 in class assignments and 1 group project] (60%)

Suggested Readings:

- Scheuren, F. (2004) *What is a Survey?* (2nd ed). American Statistical Association
- Yates, F. (1960) *Sampling Methods for Census & Surveys* (3rd ed). Charles Griffin and Company Limited
- Groves, R. M., Fowler, F. J., Couper, M. P., Lepkowski, J. M., Singer, E., & Tourangeau, R. (2009). *Survey Methodology* (2nd ed). John Wiley and Sons.

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Course title: Basic Statistical Computing (2C, 15L 30P)

Course code: ST 1012

Rationale : Since computational data analysis is an essential part of handling data analysis, competent statisticians must be able to use commonly available spreadsheet packages to solve data analysis problems. ST 1012 provides a good foundation to computational data analysis, using spreadsheet package Microsoft Excel.

Prerequisites: None

Intended learning outcomes:
After a successful completion, a student should be able to perform data management using Excel, employ Excel functions, generate Recording and VBA Macros, and analyze data at exploratory level.

Course content:
Introduction to Excel, Manipulate worksheets, Import/Export files, Templates, Advanced formatting techniques, Excel functions, Database features, Pivot tables, Record Macros, Sub procedures in VB, VBA Macros, Data analysis tool pack.

Teaching/ Learning Methods: Interactive lectures and lab sessions

Method/s of evaluation: Continuous assessments [At least 5 lab assignments] (100%)

Suggested Readings:

- Bloch, S. C. (2003) *Excel for Engineers and Scientists* (2nd ed). Wiley
- Walkenbach, J. (2013) *Microsoft Excel 2013 Bible*. Wiley
- Muir, N. C. (2007) *Teach Yourself VISUALLY Excel 2007. Wiley*
- Moore, M. (2014) *Mastering excel macros: Introduction.* Kindle

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Course Content - Level II

Course title: Basic Statistical Inference (3C, 45L)

Course code: ST 2006

Rationale: Inferential statistics use a random sample of data taken from a population to describe and make inferences about the population. Inferential statistics are valuable when examination of each member of an entire population is not convenient or possible. ST 2006 introduces the basic theory and application of Inferential Statistics.

Prerequisites: ST 1006 **or** ST 1008

Intended learning outcomes:
Upon completion of this course, students should be able to identify and compute probabilities based on sampling distributions and the central limit theorem, understand the theories of statistical inferences and apply theappropriate models in different settings to solve real-life problems, perform statistical inferences involving the mean, variance and proportion and goodness of fit tests.

Course content:
Sampling distributions, applications of central limit theorem; point estimation, bias and mean square error;
interval estimation, margin of error, determination of sample size; types of errors associated with hypothesis testing, power of the test, power curves; sampling from normal distributions, inferences about the mean and variance; large sample inference, inference for proportions; chi-square goodness-of-fit tests, chi-square tests for association.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester exam (80%) and Continuous assessment (20%) [2 in-class assignments]

Suggested Readings:

- Moore, D. S., Notz, W. I., & Fligner M. A. (2011). *The Basic Practice of Statistics* (6th ed). W. H. Freeman
- Wackerly, D. D., Mendenhall, W., & Scheaffer, R. L. (2008). *Mathematical Statistics with Applications* (7th ed). Cengage Learning

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Course title: Applications in Statistical Inference (1C ,30P)

Course code: ST 2007

Rationale: Discovering more about data with powerful statistical analysis and data visualization is very important to a statistician. ST 2007 teaches how SPSS can be used to analyze and visualize a set of data and to interpret and make conclusions based on the results.

Prerequisites: ST 1008 **&** ST 1010

Intended learning outcomes:
Upon completion of this course, students should be able to use appropriate hypothesis tests and create interval estimations to solve real world problems using SPSS. The students should also be able to manage data within the SPSS platform.

Course content:
Introduction to SPSS, Data management, Application of central limit theorem, Inference about the mean/variance of a Normal population, Inference about means/variances of Normal populations - two sample problems, Inferences about the proportions, Chi-Square test for the goodness of fit /independence.

Teaching/ Learning Methods: Practical sessions and group activities

Method/s of evaluation: Continuous assessments (100%) [At least 3 lab assignments and 1 group project]

Suggested Readings:

- Meyers, L. S., Gamst, G. C., & A. J. Guarino, A. J. (2013) *Performing Data Analysis Using IBM SPSS* (1st ed). John Wiley & Sons
- Field, A. (2013) *Discovering Statistics Using IBM SPSS Statistics* (4th ed). SAGE Publications Ltd

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Course title: Statistical Methods in Quality Control (2C, 30L)

Course code: ST 2008

Rationale: Statistical Process Control (SPC) is a set of techniques that provides a clearer understanding of the evolution and behavior of a process or system. Quality verification of a design characteristic of a manufactured product is typically achieved through inspection or sampling. This course is focused on the basic statistical methods used in quality control from the theoretical basis, classical and conventional methods to the practical aspects of the statistical process control.

Prerequisites: ST 1006 **or** ST 1008

Intended learning outcomes:
Upon successful completion of the course the student should be able to handle data using tools of Statistical Process Control (SPC), design and interpret variable and attribute type control charts by applying the basicsof control chart designs and sensitizing tools.

Course content:
Methods and philosophy of statistical quality control; Tools to enhance the quality of the process; Variable type control charts: $\bar{x}$ charts, R charts, S charts; Attribute type control charts: P charts, C charts, U charts; Control charts for short productions; Economic designs of control charts; Lot by lot acceptance sampling for attributes.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (80%) and Continuous assessment (20%)[2 in-class assignments]

Suggested Readings:

- Montgomery, D. C. (2009) *Introduction to Statistical Quality Control* (6^{th} ed). John Wiley & Sons

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Course title: Analysis of Variance and Design of Experiments (2C, 30L)

Course code: ST 2004

Rationale: Analysis of variance (ANOVA) and design of experiments are both topics that are usually covered in separate lectures. Basic methods of experimental design in the sense that how the observations or measurements should be obtained to answer a query in a valid, efficient and economical way will be discussed. The basic ANOVA to compare the averages of two or more populations are different on some dependent variable. That question is answered by appropriate calculations using sample data. This course is intended to help to understand the calculations for the simple versions of ANOVA.

Prerequisites: (ST 1006 **or** ST 1008) **and** ST2006

Intended learning outcomes:
After the successful completion, students should be able to identify the appropriate **experimental design to suit the situation where a cause and effect relationship has to be established.**

Course content:
Principles of design, Replication and randomization, Model for a completely randomized design, Analysis of variance for one–way classification, Standard errors for specific comparisons.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (80%) and continuous assessments(20%) [2 in-class assignments]

Suggested Readings:

- Kuehl, R. O. (1999). *Design of Experiments: Statistical Principles of Research Design and Analysis* 2nd ed.). Duxbury Press
- Montgomery, D. C. (2001). *Design and Analysis of Experiments* (5th ed.). John Wiley &sons

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Course title: Applied Non Parametric Methods (2C, 30L)

Course code: ST 2009

Rationale: Most of the commonly used statistical methods (parametric methods) provide valid information about the data only if the underlying population meets certain assumptions. However, when the population data has an unknown distribution, or when the sample size is small, the parametric tests cannot be used. Non-parametric methods will be used in such situations. [ST2009 provides the basic knowledge about distribution-free methods]

Prerequisites: (ST 1006 **or** ST 1008) **and** ST2006

Intended learning outcomes:
After the successful completion, a student should be able to identify situations where non-parametric methods are applicable, select the appropriate non-parametric statistical method to apply for a particular problem, apply the method and find the solution for the research question.

Course content:
Introduction, One sample location tests, Tests involving two samples, Two independent sample tests for differences in location, Two independent sample tests for differences in spread, Two related samples, Tests involving more than two samples, Miscellaneous tests, Test of randomness, Tests using frequency data.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of the semester examination (80%) and continuous assessment (20%) [2 in-class assignments]

Suggested Readings:

- Conover, W. J. (1999). *Practical Non-Parametric Statistics* (3rd ed.). Wiley & Sons
- Daniel, W. W. (2000). *Applied Non-parametric Statistics* (2nd ed.). Cengage Learning
- Lehmann, E. L., & D'Abrera, H. J. M. (2006). *Nonparametrics: statistical methods based on ranks* (1st ed.). Springer

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Course title: Introduction to Statistical Modeling (1C, 15L)

Course code: ST 2010

Rationale: The concept of Statistical modelling is introduced through this model. Various types of statistical models are discussed and taught when to use what, depending on the interest and the research question concerned. How the model changes when the main variable of interest changes is emphasized through this course.

Prerequisites: ST 1008

Intended learning outcomes:
Upon successful completion of the course the student should be able torecognize and use different forms of statistical models in the given context.

Course content:
Introduction to concept of Statistical Modeling, Building relationships between variables, Understanding the systematic and error components in modeling, Exploration of commonly used statistical models.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (80%) and Continuous assessment (20%) [2 in-class assignments]

Suggested Readings:

- Mead, R., Curnow, R. N., & Hasted, A. M. (2002). *Statistical Methods in Agriculture and Experimental Biology* (3rd ed.). CRC Press

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Industrial Statistics

Level One

	Pre Req	Course Unit	Title	Credit	Hours	IS
SI		IS 1006	Fundamentals of Statistics	3	30L30P	x
SI		IS 1007	Introduction to Statistical computing	1	30P	o
SI		MS1001	Principles of Management	1	15L	x
SII		IS 1008	Introduction to Probability and Distributions	3	45L	x
SII		IS 1009	Introduction to Survey Design	2	15L30P	o
SII		MS1003	Operational Research I	2	30L	x

Level Two

	Pre Req	Course Unit	Title	Credit	Hours	IS
SI		IS 2005	Statistical Packages	1	30P	x
SI		ST 2006	Basic Statistical Inference	3	45L	x
SI		MS2001	Statistical Quality Control	2	30L	x
SII		IS 2003	Design and Analysis of Industrial Experiments	2	30L	x
SII	ST 2006	ST 2009	Applied Non-Parametric Methods	2	30L	o
SII		ST 2010	Introduction to Statistical Modeling	1	15L	o
SII	IS 1009	MS2004	Introduction to Marketing Research	1	15L	x

Course Content - Level I

Course title: Fundamentals of Statistics (3C, 30L 30P)

Course code: IS 1006

Rationale: Statistics is very useful in many fields of study and in everyday life. One needs to have a working knowledge of the ideas and basic tools of practical statistics. [IS 1006: provides both the mechanics and the concepts needed for practical statistical work, at a level appropriate for beginners].

Prerequisites: None

Intended learning outcomes:
Upon successful completion of the course the student should be able to explore and interpret data and draw meaningful conclusions using descriptive methods using statistical software packages. The students should also be able to apply the basic concept of statistical inference through sample information and sampling distribution and formulate the inferential methods appropriately as confirmatory analysis for the descriptive methods. The students should also be able to clearly present statistical information, in both written and oral form.

Course content:
Picturing distributions with graphs: individuals and variables, categorical variables (pie charts, bar graphs), quantitative variables (histograms, stemplots, time plots), picturing distributions with graphs using statistical software; Describing distributions with numbers: measuring center (mean, median, comparing the mean and the median), measuring spread (quartiles, five-number summary, boxplots, spotting suspected outliers, standard deviation), choosing measures of center and spread, describing distributions with numbers using statistical software; organizing a statistical problem; The Normal distributions: density curve, the 68–95–99.7 rule, the standard Normal distribution, finding Normal proportions; Relationships between two quantitative variables: explanatory and response variables, scatterplots, adding categorical variables to scatterplots, measuring linear association-correlation, facts about correlation, the best fitted line using least-squares, misuses of correlation and least square relationships; Relationship between two categorical variables: marginal distributions, conditional distributions, Simpson's paradox; Introduction to statistical inference: population versus sample, random sampling designs, observation versus experiment; Sampling distributions: parameters and statistics, statistical estimation and the law of large numbers, sampling distribution of $\bar{x}$, central limit theorem; Inference in Practice - the basics: the reasoning of statistical estimation, confidence Intervals, tests of significance.

Teaching/ Learning Methods: Interactive lectures, practical sessions and group activities

Method/s of evaluation: End of semester examination (50%) and Continuous assessments [At least 3 in-class assignments, 1 group project](50%)

Suggested Readings:

- Moore, D. S., Notz, W. I., & Fligner M. A. (2011). *The Basic Practice of Statistics (6th ed).* W. H. Freeman
- Anderson, D. R., Sweeney, D. J., & Williams, T. A. (2011). *Statistics for Business and Economics* (11th ed.). South-Western College

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Course title: Introduction to Statistical Computing (1C, 30P)

Course code: IS 1007

Rationale : Computational data analysis is an essential part of modern statistics. Competent statisticians must be able to use commonly available spreadsheet packages to do data analysis and solve data analysis problems. IS 1007 is an introduction to spreadsheet package Microsoft Excel, which will give them the basic skills to grasp spreadsheet software works to suit their needs.

Prerequisites: None

Intended learning outcomes:
After a successful completion, a student should be able to perform data management using Excel and handle Excel functions and Recording Macros.

Course content:
Introduction to Excel, Manipulate worksheets, Import/Export files, Templates, Excel functions, Pivot tables, Link and embed worksheets and workbooks, Record Macros, Data analysis tool pack.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: Continuous assessments [At least 4 lab assignments](100%)

Suggested Readings:

- Bloch, S. C. (2003) *Excel for Engineers and Scientists* (2nd ed). Wiley
- Walkenbach, J. (2013) *Microsoft Excel 2013 Bible*. Wiley
- Muir, N. C. (2007) *Teach Yourself VISUALLY Excel 2007. Wiley*

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Course title: Principles of Management (1C, 15L)

Course code: MS 1001

Rationale: A sound knowledge of management concepts are essential to succeed in the corporate world. MS 1001 provides a theoretical as well as a practical framework to understand how the managerial process is executed and to it can be used to solve managerial issues.

Prerequisites: None

Intended learning outcomes:
After the successful completion of the course the students will recognize the basic concepts of management practices and apply them in a business environment.

Course content:
Concept of management and evolution of management: Scientific management and other schools of thought; Socio-Industrial imperatives for evolution of thoughts; Functional areas of Management: Planning, Organizing, Staffing, Monitoring, Evaluation; Modern management practices.

Teaching/ Learning Methods: Interactive lectures and problem based learning

Method/s of evaluation: End of semester examination (60%) and Business Cases (minimum of 3) & Presentations (40%)

Suggested Readings:

- Robbins, S. P., De Cenzo, D. A., & Coulter, M. (2012) *Fundamentals of Management: Essential Concepts and Applications* (8^{th} ed.). Pearson

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Course title: Introduction to Probability & Distributions (3C, 45L)

Course code: IS 1008

Rationale: The measure of how likely an event is to occur is termed as probability. A mathematical function that provides the probability of occurrence of various possible outcomes in an experiment is termed as probability distribution. This subject provides a broad introduction of concepts of probability based on one-dimensional and two-dimensional random variables. Further, this subject focuses on the knowledge of the probability distributions based on different types of one-dimensional random variables.

Prerequisites: IS 1006

Intended learning outcomes:
Upon successful completion of the course the student should be able to compute probabilities by applying basic rules of probability, construct the probability distribution of a random variable, expectation and variance, identify and compute probabilities based on practical situations using commonly used univariate distributions and order statistics. The student should also be able to apply the concept of two-dimensional random variables and be able to compute probabilities under joint distributions, marginal and conditional distributions and compute such probabilities.

Course content:
Basic concepts of probability: probability definitions, counting rules, probability rules, conditional probability, independence, Bayes theorem, probability theorems; One dimensional random variables: discrete and continuous distributions, expected value, expectation of functions of random variables, variance, associated theorems, moment Generating Functions, distributions of functions of random variables; Some discrete probability distributions: Bernoulli, Binomial, Poisson, Geometric, Negative Binomial; Some continuous probability distributions: Uniform, Exponential, Gamma, Normal; Relationships between distributions; Two –dimensional random variables (discrete): joint distribution, marginal and conditional distributions, independence, conditional expectation; Order Statistics: distribution of minimum, distribution of maximum.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%) [2 in-class assignments]

Suggested Readings:

- Bain, L. J., & Engelhardt, M. (1992). *Introduction to Probability and Mathematical Statistics* (2nd ed.). Brooks/Cole
- Dekking, F. M., Kraaikamp, C., Lopuhaä, H. P., & Meester, L. E. (2005) *A Modern Introduction to Probability and Statistics: Understanding Why and How*. Springer

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Course title: Introduction to Survey Design (2C, 15L 30P)

Course code: IS 1009

Rationale: The data required for certain studies are gathered via a survey conducted over a sample of individuals selected from the respective population. A properly panned survey is mandatory to collect quality data. This course introduces the important aspects in conducting survey. [IS 1009 provides foundation knowledge to conduct a survey with practical experience]

Prerequisites: None

Intended learning outcomes: Upon successful completion of the course the student should be able to formulate a real-life problem emerging from a large complex population by conducting focus group meetings with industry personal.

Course content:
Producing data via surveys: Random & nonrandom sampling methods, cautions about sample surveys, planning and designing surveys, designing a questionnaire, pretesting, margin of error; Producing data via experiments: Randomized experimental methods, cautions about experiments; Planning and designing a complex industry oriented survey: formulate a problem with the collaboration of industry via focus group meetings, develop an appropriate sampling scheme, develop questionnaire, develop implementation plan.

Teaching/ Learning Methods: Interactive lectures and group activities

Method/s of evaluation: End of semester examination (40%) and Continuous assessments [At least 2 in class assignments, 1 group project](60%)

Suggested Readings:

- Scheuren, F. (2004) *What is a Survey?* (2nd ed). American Statistical Association
- Yates, F. (1960) *Sampling Methods for Census & Surveys* (3rd ed). Charles Griffin and Company Limited
- Groves, R. M., Fowler, F. J., Couper, M. P., Lepkowski, J. M., Singer, E., & Tourangeau, R. (2009). *Survey Methodology* (2nd ed). John Wiley and Sons.

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Course title: Operational Research I (2C, 30L)

Course code: MS 1003

Rationale: Mangers in any field require to utilize available resources, plan and coordinate activities under many constraints. Operational research techniques can be used to assist such decision making activities in an optimum way.[MS1003 provides a good theoretical as well as practical foundation for basic operational research techniques]

Prerequisites: MS 1002

Intended learning outcomes:
Upon successful completion of the course, the student should be able toidentify decision variables and formulate a suitable Linear Programming model for a real situation, obtain a solution for the formulated model using an appropriate technique and use suitable software to solve the proposed models

Course content:
Introduction to Operational Research, Overview of Linear Programming, Integer Programming and Solution Techniques, Zero-One Programming and Solution Techniques, Transportation Models and Solution Techniques, Assignment Models and Solution Techniques.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (80%) and continuous assessments (20%) [2 in-class assignments]

Suggested Readings:

- Taha, H. A. (2016). *Operational Research: An Introduction* (10th ed.). Pearson
- Wagner, H. M. (1975). *Principles of Operations Research* (2nd ed.). Prentice Hall
- Hillier, F. S., & Lieberman, G. J. (2001). *Introduction to operations research* (7th ed). McGraw-Hill

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Course Content - Level II

Course title: Statistical Packages (1C,30P)

Course code: IS 2005

Rationale: Statistical software has become an essential component of the applied statistics. It is important to be familiar with a range of statistical packages. IS 2005 introduces SPSS for data analysis using basic statistical techniques and simple modeling techniques.

Prerequisites: IS 1008

Intended learning outcomes:
After a successful completion, a student should be able to perform data management using SPSS, basic data analysis using SPSS, obtain interval estimations, and perform hypothesis tests.

Course content:
Introduction to SPSS, Data Management, Numerical/ graphical summaries, Applications in hypothesis testing and confidence intervals.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: Continuous assessments [At least 4 assignments](100%)

Suggested Readings:

- Meyers, L. S., Gamst, G. C., & A. J. Guarino, A. J. (2013) *Performing Data Analysis Using IBM SPSS* (1st ed). John Wiley & Sons
- Field, A. (2013) *Discovering Statistics Using IBM SPSS Statistics* (4th ed). SAGE Publications Ltd

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Course title: Basic Statistical Inference (3C, 45L)

Course code: ST 2006

Rationale: Inferential statistics use a random sample of data taken from a population to describe and make inferences about the population. Inferential statistics are valuable when examination of each member of an entire population is not convenient or possible. ST 2006 introduces the basic theory and application of Inferential Statistics.

Prerequisites: IS 1008

Intended learning outcomes:
Upon completion of this course, students should be able to identify and compute probabilities based on sampling distributions and the central limit theorem, understand the theories of statistical inferences and apply theappropriate models in different settings to solve real-life problems, perform statistical inferences involving the mean, variance and proportion and goodness of fit tests.

Course content:
Sampling distributions, applications of central limit theorem; point estimation, bias and mean square error;
interval estimation, margin of error, determination of sample size; types of errors associated with hypothesis testing, power of the test, power curves; sampling from normal distributions, inferences about the mean and variance; large sample inference, inference for proportions; chi-square goodness-of-fit tests, chi-square tests for association.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester exam (80%) and Continuous assessment (20%)[2 in-class assignments]

Suggested Readings:

- Moore, D. S., Notz, W. I., & Fligner M. A. (2011). *The Basic Practice of Statistics* (6th ed). W. H. Freeman
- Wackerly, D. D., Mendenhall, W., & Scheaffer, R. L. (2008). *Mathematical Statistics with Applications* (7th ed). Cengage Learning

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Course title: Statistical Quality Control (2C,30L)

Course code: MS 2001

Rationale: Statistical quality control is one of the techniques used in a broader framework of quality management in various industries. Statistical techniques for monitoring and controlling the quality of manufacturing products in various aspects will be discussed. Statistical process control and acceptance sampling methods for the efficient administration of statistical quality control will be discussed. The use and application of various quality tools for generating quality improvements will also be addressed.

Prerequisites: IS 1008

Intended learning outcomes:
After a successful completion, a student should be able to identify the statistical methods for quality control and fundamentals essential for industrial process control.

Course content:
Introduction to Quality Control; Sampling Inspection: examples and definitions, usage of sampling Inspection, classification of inspection plan; Acceptance Sampling: single, OC curve, average run length, method of choosing sampling plans, inspection schemes; Control charts: control charts for variables (X-bar chart, S chart, R chart), control charts for attributes (P chart, C chart, U chart), lot by lot acceptance sampling for attributes.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (80%) and Continuous Assessments (20%) [2 in-class assignments]

Suggested Readings:

- Montgomery, D. C. (2009) *Introduction to Statistical Quality Control* (6th ed). John Wiley & Sons

- Mitra, A. (2008). *Fundamentals of Quality Control and Improvement* (3rd ed.). Wliey

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Course title: Design and Analysis of Industrial Experiments (2C, 30L)

Course code: IS 2003

Rationale: In order to establish cause and effect relationship between factors affecting a process and its output, systematic planning and analysis of experiments are needed. IS2003 provides with basic theory and application of statistical design and analysis of experiments.

Prerequisites: IS 1008 and ST 2006

Intended learning outcomes:
After the successful completion a student should be able to identify the appropriate experimental design and apply it in situations especially on industrial applicationswhere a cause and effect relationship has to be established.

Course content:
Basic elements of experimental design: experimental unit, treatments, replication, randomization; Homogeneous experimental units: completely randomized design with one-way and factorial treatment structures; Blocking for increased precision: randomized complete block, Latin square and in-complete block, designs; Factorial treatment designs; Confounding and partial confounding; Fractional replication; Response surface designs; Mixture experiments.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%) [2 in-class assignments]

Suggested Readings:

- Kuehl, R. O. (1999). *Design of Experiments: Statistical Principles of Research Design and Analysis* 2nd ed.). Duxbury Press
- Montgomery, D. C. (2001). *Design and Analysis of Experiments* (5th ed.). John Wiley &sons

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Course title: Applied Non Parametric Methods (2C, 30L)

Course code: ST 2009

Rationale: Most of the commonly used statistical methods (parametric methods) provide valid information about the data only if the underlying population meets certain assumptions. However, when the population data has an unknown distribution, or when the sample size is small, the parametric tests cannot be used. Non-parametric methods will be used in such situations. [ST2009 provides the basic knowledge about distribution-free methods]

Prerequisites: IS 1008 and ST2006

Intended learning outcomes:
After the successful completion, a student should be able to identify situations where non-parametric methods are applicable, select the appropriate non-parametric statistical method to apply for a particular problem, apply the method and find the solution for the research question.

Course content:
Introduction, One Sample Location Tests, Tests Involving Two Samples, Two Independent Sample Tests for Differences in Location, Two Independent Sample Tests for Differences in Spread, Two Related Samples, Tests Involving more than Two Samples, Miscellaneous Tests, Test of Randomness, Tests using Frequency Data.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of the semester examination (80%) and continuous assessment (20%) [2 in-class assignments]

Suggested Readings:

- Conover, W. J. (1999). *Practical Non-Parametric Statistics* (3rd ed.). Wiley & Sons
- Daniel, W. W. (2000). *Applied Non-parametric Statistics* (2nd ed.). Cengage Learning
- Lehmann, E. L., & D'Abrera, H. J. M. (2006). *Nonparametrics: statistical methods based on ranks* (1st ed.). Springer

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Course title: Introduction to Statistical Modeling (1C,15L)

Course code: ST 2010

Rationale: The concept of Statistical modelling is introduced through this model. Various types of statistical models are discussed and taught when to use what, depending on the interest and the research question concerned. How the model changes when the main variable of interest changes is emphasized through this course.

Prerequisites: IS 1008

Intended learning outcomes:
Upon successful completion of the course the student should be able to recognize and use different forms of statistical models in the given context.

Course content:
Introduction to concept of Statistical Modeling, Building relationships between variables, understanding the systematic and error components in modeling, Exploration of commonly used statistical models.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (80%) and Continuous assessment (20%) [2 in-class assignments]

Suggested Readings:

- Mead, R., Curnow, R. N., & Hasted, A. M. (2002). *Statistical Methods in Agriculture and Experimental Biology* (3rd ed.). CRC Press

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Course title: Introduction to Marketing Research (1C,15L)

Course code: MS 2004

Rationale: Marketing research is a widely used approach to gain insights about issues faced by companies. MS 2004 provides the knowledge on fundamentals in marketing research with Suggested Readings to real life case studies.

Prerequisites: IS 1009

Intended learning outcomes:
Upon successful completion of the course students should be able to apply basic statistical methods in a marketing research context. This course should further establish the fundamentals to obtain a comprehensive understanding of advanced concepts of marketing research and thereby familiarizing the student with the marketing research industry.

Course content:
Introduction, Marketing research process, Qualitative and quantitative methods used in marketing research, Defining a marketing research problem, methods of data collection in marketing research, Sampling design in marketing.

Teaching/ Learning Methods: Interactive lectures and problem based learning

Method/s of evaluation: End of semester examination (70%) and Case studies and presentations (30%)[at least 1 each]

Suggested Readings:
Parasuraman, A., Grewal, D., & Krishnan, R. (2006). *Marketing Research* (2nd ed.). South-Western College

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Statistics, Statistics with Computer Science-Special Degree

Level Three

	Pre Req	Course	Title	Credit	Hours	ST	ST+CS
SI		ST3003	Marketing Research	2	30L	o	o
SI		ST 3007	Operational Research	3	45L	o	o
SI		ST 3051	Statistical Inference I	3	45L	x	x
SI	ST 1004, ST 2004	ST 3072	Applied Regression Analysis	3	45L	x	x
SI		ST 3085	Computational Statistics	2	15L 30P	x	o
SI		ST 3074	Time Series Analysis	2	30L	x	o
SI		ST 3075	Design of Experiments	2	30L	x	
SI		ST 3076	Reliability Data Analysis	3	45L		o
SI		CS 3001	Visual Programming Technologies	3	30L 30P		x
SI		CS 3105	Computer Graphics I	3	30L 30P		o
SI		CS 3120	Machine Learning and Neural Computing	3	30L 30P		x
SI		CS 3112	Advanced Web Development	3	30L 30P		o
SI		CS 3008	Introduction to Data Structures and Algorithm	3	30L 30P	o	x
SI		PM 3056	Real Analysis 1	2	30L	o	o
SII	ST2008/ Ms2001	ST 3012	Statistical Process Control	2	30L	o	
SII		ST 3070	Special Topics	2	15L 30P	o	
SII		ST 3083	Multivariate Data analysis	3	45L	x	x
SII	ST 3051	ST 3084	Statistical Inference II	2	30L	x	x
SII		ST 3073	Survey and Sampling	3	45L	x	
SII		ST 3082	Statistical Learning I	2	60P	x	x
SII		ST3013	Essential Mathematics for Statistics	3	45L	x	x
SII		IT 3001	Management Information System	3	30L, 30P		o
SII		IT 3002	Database System	3	30L, 30P	o	o
SII		PM 3052	Real Analysis II	3	45L	o	

Level Four

	Pre Req	Course	Title	Credit	Hours	ST	ST+CS
SI		ST 4051	Scientific Writing	1	30P	o	o
SI		ST 4054	Linear Models	3	45L	x	o
SI		ST 4011	Econometrics	2	30L	o	
SI		ST 4031	Stochastic Processes and Application	3	45L	x	o
SI		ST 4052	Statistical Learning II	2	60P	x	x
SI		ST 4056	Medical Statistics	3	45L	o	
SI		CS 4104	Data Analytics	3	30L, 30P	o	x

SI		CS 4106	Computer Graphics II	3	30L, 30P		o
SI		CS 4127	Advanced Concepts in Software Design & Development	3	30L, 30P	o	x
SI		CS 4128	Advanced Database Management	3	30L 30P		x
SII		ST 4012	Special Topics for ST	2	30L	o	
SII		ST 4013	Special Topics for ST+CS	2	30L		o
SII		ST 4055	Generalized Linear Models	3	30L 30P	x	x
SII		ST 4040	Individual Project ST+CS	8	240P		x
SII		ST 4050	Individual Project ST	8	240P	x	
SII		CS 4111	Intelligent System	3	30L, 30P		o
SII		CS 4113	Natural Language Processing	3	30L 30P		o
SII		C S4117	Embedded Systems	3	30L 30P		o
SII		CS 4125	Logic Programming	3	30L 30P	o	o
SII		EC 4004	Industrial Training	0	90P	o	o

Industrial Statistics- Special Degree

Level Three

		Course	Title	Credit	Hours	IS
SI		IS 3001	Sampling Techniques	2	30L	x
SI		IS 3050	Statistical Inference	3	45L	x
SI		IS 3051	Advanced Statistical Process Control	2	30L	x
SI	ST 2006	ST 3006	Regression Analysis	2	30L	x
SI		ST 3074	Time Series Analysis	2	30L	o
SI		ST 3085	Computational Statistics	2	30L	x
SI		ST 3076	Reliability Data Analysis	3	45L	o
SI		FM 3005	Economics I for Finance and Insurance	3	45L	o
SI		MS 3002	Advanced Marketing Research	1	15L	x
SI		MS 3009	Operational Research II	3	30L 30P	o
SI		CS 3112	Advanced Web Development	3	30L 30P	o
SII		IS 3003	Special Topics I	2	15L 30P	o
SII		IS 3052	Advanced Topics in Experimental Design	2	30L	x
SII		IS 3053	Data Mining Techniques	2	15L 30P	x
SII		ST 3082	Statistical Learning I	2	60P	x
SII		ST 3083	Multivariate Data Analysis	3	45L	o
SII		MS 3004	Quality Management/Project Management	2	30L	x
SII		MS 3008	Accounting for Finance	3	45L	o
SII		IT 3002	Database Systems	3	30L 30P	o

Level Four

	Course	Title	Credit	Hours	IS
SI	ST 4051	Scientific Writing	1	30P	o
SI	IS 4002	Advanced Statistical Modeling	3	45L	x
SI	ST 4011	Econometrics	2	30L	o
SI	ST 4031	Stochastic Processes and Applications	3	45L	x
SI	ST 4035	Data Science	3	30L 30P	o
SI	IS 4003	Special Topics II	2	30L	o
SI	ST 4052	Statistical Learning II	2	60P	x
SI	MS 4007	Risk Management	2	30L	o
SI	MS 4008	Industrial Psychology	2	30L	o
SII	IS 4005	Industrial Training	4	120P	x
SII	IS 4006	Individual Project	8	240P	x
SII	FM 4007	Economics II for Finance and Insurance	3	45L	o
SII	CS 4113	Natural Language Processing	3	30L 30P	o

Course content -level III (ST, ST+CS)

Course title: Marketing Research (30L, 2C)

Course code: ST 3003

Rationale: Marketing research is a widely used approach to gain insights about issues faced by companies. ST 3003 provides an introduction to the methodologies adopted in marketing research with references to real life case studies.

Prerequisites: - None

Intended learning outcomes: Upon successful completion of the course, the students should be able to understand and identify key aspects of the marketing research process, appraise basic methodological frameworks in marketing research in different scenarios, design and formulate a marketing research along theoretical concepts.

Course content:
Introduction, The Marketing Research Process, Defining the problem with exploratory research, Survey research: Methods of communication with respondents, Test marketing, Measurements and Attitude scaling, Questionnaire design, Sampling procedures, Data analysis, report writing and presentation: Stochastic models of brand choice, Applications of General Linear Models in marketing, Conjoint analysis, Correspondence analysis, Advertising media models, Marketing response models.

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End-of-semester examination (80%) and continuous assessment (20%) [2 in-class assignments]

Suggested Readings:

- Lehmann, D.R., Gupta, S. & Steckel, J.H. (1998). *Marketing Research*. Addison-Wesley
- Crask, M., Fox, R. J, & Stout, R. G. (1995). *Marketing research: principles and applications*. Prentice Hall, Englewood Cliffs, N.J

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Course title: Operational Research (3C, 45L)

Course code : ST 3007

Rationale: Managers in any field require to utilize available resources, plan and coordinate activities under many constraints. Operational research techniques can be used to assist such decision-making activities in an optimum way. [ST3007 provides a good foundation about some of the widely used operational research techniques]

Prerequisites: AM 2003

Intended learning outcomes: Upon successful completion of the course, the students should be able to: describe the fundamental concepts of real world applications in operational research, model decision making problems, obtain solution/s for the formulated model/s using appropriate techniques and software packages.

Course content:

Integer Programming models and solution techniques (Cutting Plane algorithm, Branch-and-Bound algorithm), Zero-one Programming models (mind expanding problems),Transportation models and solution techniques (North-West Corner method, Least Cost method, Vogel's Approximation method, U-V Method), Assignment models and solution techniques(Hungarian method), Inventory Models (Deterministic inventory models with shortages and without shortages),Queuing models (Elements of a queuing model, steady-state measures of performance, single-server models, multiple-server models),Solution techniques using suitable OR packages.

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End of semester examination (70%) and continuous assessment (30%) [2 in-class assignments]

Suggested Readings :

- Taha, H. A. (1997). *Operations research: an introduction* (6th ed). Prentice Hall, Upper Saddle River, N.J
  Verma, A. P. (2009). *Operational Research* (3rd ed). S. K. Kataria & Sons.
- Panneerselvam, R. (2006). *Operational Research* (2nd ed). PHI Learning Pvt. Ltd.
- Wagner,H. M. (1975). *Principles of operations research: with applications to managerial decisions* (2nd ed). University of Michigan
- Hillier, F. S., & Liebermann, G.D. (1980). *Operations research* (3rd ed). Holden-Day

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Course title: Statistical Inference I – [3credits (45L), For ST (core), ST+CS (core)]

Course code: ST 3051

Rationale: In data analysis, statistical inference is an essential tool to determine if an observed difference is really due to chance alone or due to some actual effect/s of a treatment/s or an agent. [The subject ST 3051 carries a theoretical foundation for one part of this tool, namely, estimation].

Prerequisites: None

Intended Learning Outcomes: Upon successful completion of the course, students should be able to recognize the underlying theory behind statistical estimation, apply the necessary techniques to find estimates of population parameters and appraise the properties of estimators.

Course Content: Generating moments using characteristic function; Sampling from Normal population: sampling distributions of sample mean and sample variance (s^2), independence of sample mean and s^2; Properties of estimators: Mean-squared error, Unbiasedness, Consistency, Sufficiency, Completeness, Efficiency; Factorization criterion; Variance Reduction: Cramer-Rao Lower Bound, Rao-Blackwell Theorem, Lehmann-Scheffe' Theorem; Methods of Estimation: Method of moments, Maximum Likelihood and Its Properties, Least Squares; Interval Estimation: Pivotal Method, General Method.

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End-of-semester examination (70%) and continuous assessment (30%) [2 in-class assignments]

Suggested Readings:

- Hogg, R. V., McKean, J. W., & Craig, A. T. (2018). *Introduction to Mathematical Statistics* (8th ed). Pearson
- Lindgren, B. (2017). *Statistical Theory* (4th ed). CRC Press
- Mood, A. M., Graybill, F. A., & Boes, D.C. (1974). *Introduction to the Theory of Statistics* (3rd ed). McGraw-Hill

Course title: Applied Regression Analysis – [3credits (45L), For ST (core), ST+CS (core)]

Course code: ST 3072

Rationale: Regression analysis is a popular statistical tool used to explore and establish linear relationship between a specific response variable and several other variables. ST3072 provides with theory and application of linear regression models.

Prerequisites: ST1004 and ST2004

Learning Outcomes: At the completion of the course, the students should be able to formulate a suitable regression model to describe a relationship between a response variable and one or more explanatory variables. The students will also be able to apply appropriate diagnostics to evaluate the model and interpret the model to describe the problem.

Course Contents: Simple Linear Regression: introduction, correlation, uses of Regression, simple linear Regression model, parameter estimation, inferences about the model, prediction, coefficient of determination; Model Adequacy: residuals, outliers, lack of fit, transformations; Multiple Linear Regression: Multiple Linear Regression model, parameter estimation, inferences about the model, prediction, model adequacy, variable selection methods, use of categorical variables as predictors, analysis of co-linearity; Transformation of Variables; Polynomial regression; weighted least square

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and continuous assessment (30%) [2 in-class assignments]

Suggested Readings:

- Draper, N.R., & Smith, H. (1998). *Applied Regression Analysis* (3rd ed). Wiley
- Kleinbaum, D. G., Kupper, L. L., Muller, K. E., & Nizam, A. (1997). *Applied Regression Analysis and Other Multivariable Methods* (3rd ed). Duxbury Press
- Chatterjee, S., & Hadi, A. L. (2012). *Regression Analysis by Example* (5th ed). Wiley
- Montgomery, D. C., Peck E. A., & Vining, G. (2007). *Introduction to Linear Regression Analysis* (4th ed). Wiley

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Course title: Computational Statistics – [2 credits (30L), For ST (core), IS(core) ST+CS (optional)]

Course code: ST 3085

Rationale: Computational statistics refer to the computational methods that enable statistical methods. This course provides students some widely used such methods and techniques using the free and open source statistical software, R.

Prerequisites: None

Learning Outcomes: After a successful completion, students should be able to generate random numbers; simulate data; apply bootstrap methods to analyze data.

Course Content: Introduction to Random numbers: pseudo random numbers, properties of random numbers, testing for basic properties, software for random number generation; Introduction to Simulation: simulation of random variables, Monte Carlo simulation methods, simulation of inventory models, simulation of queuing models; Data Re-sampling: Introduction to Bootstrap, Bootstrap estimation of Variance, Bootstrap Confidence Intervals, Introduction to EM algorithm.

Teaching/ Learning Methods: Interactive l**ectures and lab sessions**

Method/s of evaluation: End-of – semester examination (70%) and continuous assessments (30%) [2 in-class assignments]

Suggested Readings:

- Givens, G. H., & Hoeting, J. A. (2012). *Computational Statistics* (2nd ed). Wiley
- Gentle, J. E (2005). *Elements of Computational Statistics*. Springer
- Efron, B., & Tibshirani, R. J. (1993). *An introduction to the bootstrap* (1st ed). Chapman and Hall/CRC

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Course title: Time Series Analysis– [2credits (30L), For ST (core), ST+CS (optional)]

Course code: ST 3074

Rationale: Time series analysis usually studies patterns in data evolving over time (time series data) and use these patterns to forecast the future behavior. For e.g., next month sales of a company can be forecasted by studying patterns in past sales data of that company. ST 3074 provides necessary tools and theories to study and forecast time series data.

Prerequisites: None

Learning Outcomes: Upon the successful completion students should be able to model and forecast univariate time series.

Course Content: Introduction: definition, types of time series, components of time series, time plot, time series decomposition, transformation, differencing, autocorrelation; Stationarity: stationary & non-stationary time series, tests for stationarity; Modelling time series: time series models, model identification, parameter estimation, diagnostic checks, forecasting.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (80%) and In-class Assignments (20%) [2 in-class assignments]

Suggested Readings:

- Makridakis, S. G., Weelwright, S. C., & Hyndman, R. J. (1997). *Forecasting Methods and Applications* (3rd ed). Wiley
- Chatfield, C (2003). *The analysis of Time Series: An Introduction* (6th ed). Chapman and Hall/CRC
- Box, G. E. P., Jenkins, G. M., & Reinsel, G. C. (1994). *Forecasting and Control* (3rd ed). Prentice Hall

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Course title: Design of Experiments – [2credits (30L), For ST (core)]

Course code: ST 3075

Rationale: If one wants to establish cause and effect relationship in experimentation, one needs to have an experiment statistically designed. [ST 3075 provides a good foundation for this aspect with details of several commonly used statistical designs].

Prerequisites: None

Intended Learning Outcomes: :At the end of the course student are expected to employ basic planning and designing skills to propose suitable experimental designs, analyze data and interpret results to answer specific questions in comparative experiments.

Course Content: Principles of planning and designing comparative experiments; Review of ANOVA and related topics; Basic designs: completely randomized design (CRD), randomized complete block design (RCBD), Latin squares/multiple Latin squares, treatment contrasts and mean comparisons; Factorial experiments (2k and others); confounding and partial confounding in 2k experiments; split-plot designs; analysis of covariance.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (70%) and continuous assessments (30%) [2 in-class assignments]

Suggested Readings:

- Montgomery, D. C. (2017). Design and analysis of experiments (9^{th} ed). Wiley
- Kuehl, R.O. (1999). *Design of Experiments: Statistical principles of research design and analysis* (2^{nd} ed). Duxbury Press
- Box, G. E. P., Hunter, W. G., & Hunter, J. S. (1978). *Statistics for experiments: An introduction to design, data analysis and model building*. John Wiley & Sons

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Course title: Multivariate Data Analysis– [3credits (45L), For ST (core), ST+CS (core), IS (elective)]

Course code: ST 3083

Rationale: In real life, many processes are affected by the actions of not only one variable but several variables simultaneously. For eg., a heart attack may be the result of a combination of factors like excess weight, high blood pressure, high cholesterol, genetic effects, etc. etc. Multivariate analysis is a natural tool to analyze several variables (possibly correlated) at the same time to have insight of the combined effect, if any. [ST 3083 provides a good theoretical as well as practical foundation for commonly used multivariate techniques].

Prerequisites: None

Intended Learning Outcomes: After a successful completion, students should be able to make decisions based on multivariate hypothesis tests; carryout dimension reduction methods; clustering data and discriminate new observations to pre-defined clusters

Course Content: Review of matrix algebra; Mean and variance-covariance of a random vector; correlation matrix; Properties of multivariate normal distribution and applications; Checking for multivariate normality; Hypothesis testing using multivariate tests; MANOVA ; Principal component analysis; Factor analysis; Discriminant analysis; Cluster analysis.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (70%) and continuous assessments (30%) [2 in-class assignments]

Suggested Readings:

- Johnson, R. A., & Wichern, D. W. (2012). *Applied multivariate statistical analysis* (6th ed). Phi Learning Private Limited
- Morrison, D. F. (2004). *Multivariate statistical methods* (4th ed). Duxbury Press
- Johnson, D. E. (1998). *Applied multivariate methods for data analysts* (1st ed). Duxbury Press

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Course title: Statistical Inference - II– [2credits (30L), For ST (core), ST+CS (core)]

Course code: ST 3084

Rationale: In data analysis, statistical inference is an essential tool to determine if an observed difference is really due to chance alone or due to some actual effect/s of a treatment/s or an agent. [The subject ST 3084 carries a theoretical foundation for one part of this tool, namely, testing statistical hypotheses].

Pre-requisites: ST 3051

Intended Learning Outcomes: Upon successful completion of the course, students should be able to recognize the underlying general theory behind testing statistical hypotheses and apply the necessary techniques to real life situations.

Course Content: Parametric Inference: Introduction to Hypothesis Testing, Errors, Power, Neymann-Pearson Lemma, Most Powerful Tests, Uniformly Most Powerful Tests, Likelihood Ratio Tests, Sequential Tests, Sequential Probability Ratio Test (SPRT), Wald's Identity, Average Sample Number (ASN); Distribution-free Inference: Tests of Randomness, Run Tests, One sample Location Tests for Median, Sign Test; Asymptotic Relative Efficiency (ARE); Two sample Location problem.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (70%) and continuous assessments (30%) [2 in-class assignments]

Suggested Readings:

- Mood, A.M., Graybill, F. A., & Boes, D.C. (1974). *Introduction to the Theory of Statistics* (3rd ed). McGraw-Hill
- Lindgren, B. W. (1976). *Statistical Theory* (3rd ed). Macmillan
- Hogg, R. V., & Craig, A. T. (1970). *Introduction to Mathematical Statistics* (3rd ed). Macmillan

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Course title: Survey and Sampling – [3credits (45L), For ST (core)]

Corse Code: ST3073

Rationale: Sampling is the process of selecting a representative group from a population. While many surveys and samples give valuable information; some, unfortunately don't. This course concentrates on the statistical aspects of taking and analyzing a sample. It gives guidance on how to tell when a sample is valid or not, and how to design and analyze many different forms of sample surveys. [ST 3073 provides a good theoretical as well as practical foundation for sampling techniques used in practice]

Prerequisites: None

Intended Learning Outcomes: After the completion of the course, the students should be able to recognize the building blocks and the theory of random sampling design a survey and be able to estimate parameters based on the design of the study.

Course Content: Fundamentals of probability sampling and estimation; Simple Random Sampling: theory involved in estimation procedures, sampling weights, estimating population mean, variance, total & proportion, estimating a ratio & its variance, estimation using Ratio and Regression methods and their properties, Sample size determination; Stratified Random Sampling: proportional and optimal cost allocation to strata, estimating population mean, variance, total & proportion, overview of advanced topics in stratified random sampling, Estimating a ratio & its variance, regression estimators, sample size determination, post-stratification, quota sampling; Cluster Sampling: overview of cluster sampling, clustering with equal and unequal probabilities, sample size determination, design effect and intra-cluster correlation; Multi-stage sampling: Complex surveys and related problems, sources of errors in surveys.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (70%) and continuous assessments (30%) [2 in-class assignments]

Suggested Readings:

- Lohr, S. L. (2009). *Sampling: Design and Analysis* (2nd ed). Cengage Learning
- Cochran, W. G. (2007). *Sampling Techniques* (3rd ed). Wiley India Pvt. Limited
- Barnet, V. (1974). *Elementary Sampling Theory.* Routledge
- Kish, L. (1995). *Survey Sampling.* Wiley

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Course title: Statistical Learning I - [2credit (60P), For ST (core), ST+CS (core), IS (core)]

Course code: ST 3082

Rationale: Statistical learning provides essential modern toolset to analyze vast and complex data sets that have emerged in fields such as biology, finance, marketing etc. ST presents some important modeling techniques and prediction techniques such as ridge regression, LASSO, elastic net, principle component regressions etc., along with relevant applications.

Prerequisites: None

Indented learning outcomes: Upon completion of this course, student should be able to explore complex data sets, select appropriate statistical techniques to solve problems involved and justify their choice. The students should be able to implement these techniques using an appropriate programming language, evaluate the results and explain the results to non statisticians using non statistical terms.

Course Contents: Introduction to statistical learning; Advanced regression model: understanding models, variable selection, validation and cross validation, Shrinkage method and ridge regression, Lasso, principal component regression and partial least squares; Resembling method: cross validation, bootstrap; Classification: understanding classification problems using logistic regression, multivariate logistic regression, and discriminate analysis.

Teaching/ Learning Methods: Interactive lectures, problem based learning, independent learning activities and group activities

Method/s of evaluation: Continuous assessments (85%) [4 group projects and presentations] and attendance (15%)

Suggested Readings:

- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An Introduction to Statistical Learning: with Applications in R* (2013). Springer Science & Business Media

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Course title : Reliability Data Analysis – [3credits (45L), For ST+CS(core), IS (elective)]

Course code : ST 3076

Rationale: Analysis of lifetime data/ failure time data is complicated due to the presence of censored observations arising from the non-failed units in the data. Therefore, specialized methods of analysis are available for analysing such duration data. [ST 3076 provides a fundamental theoretical foundation as well practical foundation on statistical methods for analysing duration data].

Prerequisites: None

Intended Learning Outcomes:
Upon successful completion of the course, the students should be able to: describe the features of reliability data, calculate non-parametric estimations for reliability data. Model reliability data using suitable failure time regression models

Course Content: Reliability concepts and Reliability data. Models, censoring and likelihood for failure time data. Non-parametric estimation**,** Location-Scale based parametric distributions. Parametric likelihood fitting concepts: Maximum likelihood estimates for the exponential mean based on the density approximation. Failure time regression analysis: failure time regression models. Accelerated failure time models. Proportional hazards model, weibull proportional hazards model. Accelerated test models. Planning accelerated life tests

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and continuous assessment (30%)[2 in-class assignments]

Suggested readings:

- Meeker, M.Q., & Escobar, L.A. (1998). *Statistical methods for reliability data.* Wiley
- Wolstenholme L.C. (1999). *Reliability Modeling: A Statistical approach* (1st ed). Chapman and Hall/CRC

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Course title: Statistical Process Control (2C, 30L)

Course code: ST 3012

Rationale: Cumulative sum (CUSUM) and exponentially weighted moving average (EWMA) Control Charts are capable of detecting small shifts in process parameters, leading to more effective process monitoring, as opposed to traditional Shewhart's control charts which misjudge the occurrence of small process shifts. When there is more than one process parameter, to detect shifts in these, Multivariate Control Charts are used. In addition to these Control Charts capability analysis, acceptance sampling schemes and process optimization techniques will also be discussed.

Prerequisites: ST 2008/ MS2001

Intended learning outcomes:
Upon successful completion of the course the student should be able to investigate and analyze process capability, advanced charts and control charts for correlated data. The student should also be able to recognize the statistical quality control methods using acceptance sampling, response surface approach for optimizing the process.

Course content:
Capability analysis; Cumulative Sum (CUSUM) control charts; Exponentially Weighted Moving Average (EWMA) Charts; Acceptance sampling: double, sequential, multiple; Decision theory approach; Multivariate control charts; Process optimization with design experiment.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (80%) and continuous assessment (20%)[2 in-class assignments]

Suggested Readings:

- Montgomery, D. C. (2008). *Introduction to Statistical Quality Control* (6th ed). Wiley
- Duncan, A. J. (1974). *Quality Control and Industrial Statistics* (4th ed). R. D. Irwin

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Course title: Special Topics (30L, 2C)

Course code: ST 3070

Course content: Selected topics depending on the availability of teaching staff.

Teaching/ Learning Methods: Interactive lab sessions and assignments

Evaluation Criteria: Examinations (80%) and continuous assessments (20%)[2 in-class assignments]

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Course title: Essential Mathematics for Statistics – [3 credit (45L), For ST (core), ST+CS (core), IS (core), 4G (core)]

Course code: ST 3013

Rationale: Mathematical theories such as linear algebra, matrices, calculus etc. are required for proves of most of the higher level statistical theories. ST 3013 provides those tools for students with required amount of theoretical knowledge.

Prerequisites: None

Learning Outcomes: After a successful completion, students should be able to apply basic mathematical tools in solving theoretical and practical problems in Statistics.

Course Content: Linear algebra: Linear dependence, rank and the solution of homogeneous equations, characteristic polynomials, eigenvalues , eigenvectors, spectral theorem for symmetric matrices, idempotent matrices and properties, orthogonal projections, trace of a matrix and properties, positive definite/semi definite matrices, quadratic forms, differential calculus in matrix notation, direct product (kronecker)of any two matrices, generalized inverse /conditional inverse ; Calculus: Concepts of functions, limits and continuity, L'Hopital's rule, the fundamental theorem of calculus, approximation of definite integrals, Improper integrals; Series and Sequences: sequences and their convergence, series and convergence of series, power series and their convergence of radius, Taylor series and their application; Several variable calculus: functions of several variables, continuity, differentiability, derivatives, multiple integrals, change of variables

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%)[2 in-class assignments]

Suggested Readings:

- Graybill, F. A. (2001). *Matrices with applications in Statistics* (2nd ed). Brooks/Cole
- Bonar, D. D., & Khoury, M.J. (2006). *Real Infinite Series* (1st ed). American Mathematical Society
- Courant, R., & John, F. (1965). *Introduction to Calculus and Analysis, Volume 1*. Springer-Verlag
- Lang, S. (1987). *Calculus of several variables* (3rd ed). Springer

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Course content -level IV (ST, ST+CS)

Course title: Econometrics (30L, 2C)

Course code : ST 4011

Rationale: Analysis of economic and financial data requires the formulation a unique methodological framework. ST 4011 provides the theoretical as well as a practical foundation for the students to analyze and make accurate projections of economic and financial data.

Prerequisites: None

Intended Learning Outcomes: Upon successful completion the students will be able to apply statistical methods in the context of economics and carry out a successful econometric analysis.

Course content: Linear regression model and properties of least squares estimates; Autocorrelation; Heteroscedasticity; Multicollinearity; Model specification; Simultaneous equations; Unit roots, Non-stationary and Cointegration.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (80%) and Continuous assessment (20%)[2 in-class assignments]

Suggested Readings:

- Pindyck, R. S., & Rubinfeld, D. L. (1998). *Econometric Model and Economic Forecasts* (4th ed). Irwin/McGraw-Hill
- Wooldridge, J. M. (2015). *Introductory Econometrics: A Modern Approach* (6th ed). Cengage Learning
- Greene, W.H. (2012). *Econometric Analysis* (7th ed). Pearson Education
- Johnston, J., & DiNardo, J. (1996). *Econometric Methods* (4th ed). McGraw-Hill/Irwin

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Course title: Medical Statistics –[3credits (45L), For ST (elective)]

Course code: ST 4056

Rationale: Medical statistics constitutes statistical methods for analyzing data on medicine and health sciences which include epidemiology, public health, forensic medicine and clinical research. [ST 3077 provides both theory and applications on statistical methods for analyzing medical data]

Prerequisites: None

Intended Learning Outcomes: At the successful completion student should be able to define, compute and interpret statistics; identify and apply statistical models in epidemiology, clinical trials, and survival studies in order to analyze data from medical studies.

Course Contents: Introduction; Epidemiology: basic designs for epidemiological studies, relative risk and odds ratio, confounding and interaction; Analysis of data from cohort and case control studies; Matched case control studies; Logistic regression; Clinical trials: introduction, protocols for clinical trials, cross-over designs, allocation to treatment, sample size determination, Phase I and Phase II studies; Survival Analysis: analysis of survival data, the survival and hazard functions; Non-parametric procedures: Kaplan-Meier estimate of survivor functions, log-rank test for comparing two survival times; Parametric modeling: proportional hazards model, Cox's proportional hazards model.

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End of semester examination (80%) and continuous assessment (20%)[2 in-class assignments]

Suggested Readings:

- Armitage, P. (2017). *Statistical methods in medical research* (4^{th} ed). Wiley India
- Case-control studies

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Course title: Scientific Writing - [1credit (30P), For ST (optional), ST+CS (optional), IS (optional)]

Course code: ST 4051

Rationale: Scientific writing is essential for communication of scientific knowledge in the form of reports, dissertations, journal papers and thesis. It is necessary that students become more effective writers by communicating the results or findings, academically and professionally. Summarizing, literature review, writing articles, referencing and citing are the main aspects focused in this course.

Prerequisites: None

Learning Outcomes: Upon completion of this course, student should be able to search, identify, read, and analyze research articles which are relevant to their research activities; Write a quality scientific literature review for a selected research problem.

Course content: Read and discuss text/papers for a general sense of what research is/are about, how one thinks when doing research, and what the major research activities are; Identify research articles from different areas of statistics/computer science, involving different methodologies of research, and abstract them; Select an area related to statistics, which is of particular interest to students, write a professional quality literature review for a problem of your choice.

Teaching/ Learning Methods: Interactive lectures and independent learning activities

Method/s of evaluation: Continuous assessment (100%)[at least 2 assignments]

Suggested Readings:

- Peer reviewed journal papers

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Course title: Generalized Linear Models – [3credits (30L, 30P), For ST (Core), ST+CS (core)]

Course code: ST 4055

Rationale: Generalized Linear models describe a response variable from an exponential family as a linear function of one or more predictor variables. For example, we may have binomial, Poisson, gamma etc distribution for response variables. ST 4055 provides a thorough theoretical and practical foundation in fitting, estimating, interpreting and testing in generalized linear models.

Prerequisites: None

Intended Learning Outcomes: At the completion of the course, the students should be able to identify and apply a suitable generalized linear model for a given dataset. Student should also be able to apply appropriate diagnostics to evaluate the model.

Course Content: Introduction to Statistical modeling; Exponential family and GLMs: estimation, inference; Logistic regression: binary logistic model, link function, over dispersion and bio-assay, multinomial logistic model, ordinal logistic model; Log-linear models: contingency tables, link function; comparison of logistic and log-linear models; Gamma models; Model Adequacy: residuals, outliers, lack of fit.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: End of semester examination (70%) and continuous assessment (30%)[at least 2 assignments]

Suggested Readings:

- Agresti, A. (2012). *Categorical Data Analysis* (3rd ed). Wiley
- Collett, D. (1991). *Modelling Binary Data* (2nd ed). Taylor & Francis
- McCullah, P., & Nelder, J. A. (1989). *Generalized Linear Models* (2nd ed). Chapman and Hall/CRC
- Aitkin, M., Anderson, D., Francis, B., & Hinde, J. (1989). *Statistical Modelling in GLIM.* Oxford University Press

Course title: Stochastic Processes and Applications – [3credit (45L), For ST (core), ST+CS (core), IS (core)]

Course code: ST 4031

Rationale: Stochastic processes underlie many ideas in statistics such as time series, Markov chains, Markov processes, Poisson Processes etc. Thus, Stochastic Process helps to understand the applications of Statistics in a simpler way and in a more commanding fashion. In addition, it enable to develop models for situations of interest. ST4031 provides sound theoretical and practical foundation for stochastic process.

Prerequisites: None

Intended Learning Outcome: Upon successful completion of this course, students should be able to recognize the properties of basic stochastic processes and apply the knowledge of probability theory and stochastic processes to analyze problems in practice.

Course Content: Generating function; Basics of Brownian motion; Poisson process; Random walks; Discrete parameter Markov Chains; Continuous parameter Markov Chains; Branching process; Birth and Death processes; Queuing processes.

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End of semester examination (70%) and continuous assessment (30%)[2 in-class assignments]

Suggested Readings:

- Bailey, N. T. J. (1970). *The Elements of Stochastic Processes*. John Wiley
- Feller, W. (2008). *An Introduction to Probability Theory and Applications* (2nd ed). Wiley India Pvt. Limited
- Cox, D. R., & Miller, H. D. (1977). *The Theory of Stochastic Processes.* Chapman and Hall/CRC
- Trivedi, K. S. (2016). *Probability and Statistics with Reliability Queues and Computer Science Applications* (2nd ed). Wiley

Course title: Statistical Learning II - [2credit (60P), For ST (core) , ST+CS (core), IS (core)]

Course code: ST 4052

Rationale: Statistical learning provides essential modern toolset to analyze vast and complex data sets that have emerged in fields biology, finance, marketing etc. ST4052 presents some important classification and clustering techniques such discriminant analysis, bagging, random forest, boosting, k-means clustering etc., along with relevant applications.

Prerequisites: None

Indented learning outcomes: Upon completion of this course, student should be able to explore complex data sets, select the relevant statistical techniques discussed to solve problems involved and justify their choice. The students should be able to implement these techniques using an appropriate programming language, evaluate the results and explain the results to non statisticians using non statistical terms.

Course Contents: Moving beyond linearity: polynomial regression, regression splines, smoothing splines; Tree-based methods: the basics of decision tree, bagging, random forest, boosting; Support Vector machines; Unsupervised learning: dimension reduction techniques, clustering

Teaching/ Learning Methods: Interactive lectures, problem based learning, independent learning activities and group activities

Method/s of evaluation: Continuous assessments (85%) [4 group projects and presentations] and attendance (15%)

Suggested readings**:**

- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An Introduction to Statistical Learning* (1st ed.). Springer-Verlag New York

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Course title: Linear Models – [3credits (45L), For ST (core), For ST+CS (optional)]

Course code: ST 4054

Rationale: Linear models describe a continuous response variable as a function (linear in parameters) of one or more predictor variables. For example, we may explain credit card balance as a function (linear in parameters) of average monthly income, gender, student status etc. Linear models can be utilized to describe and predict the behavior of complex systems. ST 4052 provides thorough theoretical foundation for regression and design models with aid of linear algebra.

Prerequisites: None

Intended Learning Outcomes: Upon successful completion of the course, students should be able to recognize the fundamentals of the general linear model, distinguish between different linear models found in real life situations and appraise the optimal estimation and inference related to different linear models.

Course Content: Elementary linear and matrix algebra: idempotent matrices, trace of matrices, generalized and conditional inverses; Solutions of linear equations; Derivatives of quadratic forms; Expectation of random matrices; Multivariate normal distribution and its properties; Distribution of quadratic forms; General linear model: optimal estimation and hypothesis testing, applications to regression model, continued application of optimal inference, design models, estimability, solving normal equations, components of variance models and mixed models

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End-of-semester examination (70%) and assignments (30%)[2 in-class assignments]

Suggested Readings:

- Graybill, F. A. (2000). *Theory and applications of the linear model.* Duxbury
- Graybill, F. A. (2001). *Matrices with Applications in Statistics* (2nd ed.). Brooks/Cole
- Christensen, R. (2013). *Plane answers to complex questions* (2nd ed.). Springer Science & Business Media

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Course title: Industrial Training (3 EC, 90P)

Course code: EC 4004

Prerequisites: None

Rationale: Industrial training provides firsthand experience for the undergraduates to work fulltime in an organization outside the university. The main intention of the programme is to enhance their communication and teamwork skills. They will also be conducting real-time applications using the knowledge they gained at the university while improving their ability to explore new techniques.

Intended learning outcomes:
Upon completion of Industrial Training, the student should be able to integrate classroom theory with workplace practice, develop greater clarity about academic and career goals, recognize administrative functions and company culture, appreciate the ethical basis of professional practice in relevant industry, display a capacity for critical reasoning and independent learning, explore options in career plans and goals.

Course content: Industrial training provides students to understand and appreciate real-life working experiences. Students may realize their ambition and ascertain their career path from the experience gained during industrial training. The training provides students the opportunity to meet and network with people in the industry, and for the industry the opportunity to identify talents and potential skilled employees.

Teaching/ Learning Methods: Independent learning activities

Method/s of evaluation: 100% based on continuous assessments

- Student Progress & Progress Reports (25 %)
- External supervisor/s (25 %)
- Final Report (50 %)

Suggested Readings : None

Course content -level III (IS)

Course title: Sampling Techniques [2Credits, 30L, , For IS (core)]

Course code: IS 3001

Rationale: This course concentrates on the statistical aspects of taking and analyzing a sample. It gives guidance on how to how to design and analyze many different forms of sample surveys. [IS 3001 provides a good theoretical as well as practical foundation for sampling techniques used in practice]

Prerequisites: None

Intended Learning Outcomes: Upon successful completion, the students should be able to identify and effectively use (put in to practice) the sampling techniques that are commonly used in statistics.

Course Content: Simple Random Sampling (SRS), Sample size determination, Ratio and Regression estimators under SRS, Stratified, Systematic, and Quota sampling. Separate and combined estimators for stratified sampling. Cluster sampling, Multi-stage sampling, Complex sample designs and related issues.

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End-of-semester examination (70%) and assignments (30%)[2 in-class assignments]

Suggested Readings:

- Thompson, S. K. (2002). *Sampling* (2nd ed.). John Wiley & Sons
- Som, R. K. (1995). *Practical sampling Techniques* (2nd ed.). CRC Press
- Rao, P. S. R. S., & Myron J. Katzoff, M. J. (2010). *Hand book of Sampling Techniques and Analysis* (1st ed.). CRC Press

****

Course title: Statistical Inference – [3credits (45L), For IS (core)]

Course code: IS 3050

Rationale: In data analysis, statistical inference is an essential tool to determine if an observed difference is really due to chance alone or due to some actual effect/s of a treatment/s or an agent. [The subject IS 3050 carries a theoretical foundation for one part of this tool, namely, estimation].

Prerequisites: None

Intended Learning Outcomes: Upon successful completion of the course, students should be able to recognize the underlying theory behind statistical estimation, apply the necessary techniques to find estimates of population parameters and appraise the properties of estimators.

Course Content: Generating moments using characteristic function; Sampling from Normal population: sampling distributions of sample mean and sample variance (s^2), independence of sample mean and s^2; Properties of estimators: Mean-squared error, Unbiasedness, Consistency, Sufficiency, Completeness, Efficiency; Factorization criterion; Variance Reduction: Cramer-Rao Lower Bound, Rao-Blackwell Theorem, Lehmann-Scheffe' Theorem; Methods of Estimation: Method of moments, Maximum Likelihood and Its Properties, Least Squares; Interval Estimation: Pivotal Method, General Method.

Teaching/ Learning Methods: **Interactive lectures**

Method/s of evaluation: End-of-semester examination (70%) and assignments (30%)[2 in-class assignments]

Suggested Readings:

- Hogg, R. V. (2018). *Introduction to Mathematical Statistics* (8th ed.). Pearson
- Lindgren, B. (1993). *Statistical Theory* (4th ed.). CRC Press
- Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). *Introduction to the Theory of Statistics* 3rd Edition (3rd ed.). McGraw-Hill

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Course title: Advanced Statistical Process Control – [2credits (30L), For IS (core)]

Course code: IS 3051

Rationale: Traditional Shewhart's control charts are effective in detecting large shifts in a process but unable to find moderate or small size of shifts quickly. Continuing undetected processes for long periods incur much larger total costs than rapidly detecting large shifts. Cumulative sum (CUSUM) and exponentially weighted moving average (EWMA) control charts largely plugs this gap, leading to much more effective process monitoring. Apart from the control charts Process and gauge capability and acceptance sampling schemes will be discussed.

Prerequisites: None

Intended Learning Outcomes: Upon successful completion of the course, students should be able to perform analysis of process capability and measurement system capability, Design, use, and interpret cumulative sum control chart control charts, Design, use, and interpret exponentially weighted moving average control charts, Demonstrate the ability to design, use, and interpret operating characteristic curve, Demonstrate the ability to use acceptance sampling for statistical process control.

Course Content Process and measurement system capability analysis, Cumulative sum control charts, Exponentially weighted moving average control charts, Univariate process monitoring and control systems, Multivariate process monitoring and control systems, Attribute type sampling schemes, Variable type sampling schemes, Taguchi method

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (80%) and assignments (20%)[2 in-class assignments]

Suggested Readings:

- Montgomery, D C. (2009*). Introduction to Statistical Quality Control*. (6th ed.). John Wiley and Sons, Inc.
- Amitava, M (2001). *Fundamentals of Quality Control and Improvement*, (3rd ed.)., Wiley and Sons, Inc.,
- Ryan, T.P. (2011). *Statistical Methods of Quality Improvement*, (3rd ed)., John Wiley & Sons

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Course title: Regression Analysis – [2credits (30L), For IS (Core)+Applied Stat. Theme]

Course code : ST 3006

Rationale: Regression Analysis is essential when relationships between and among variables are to be studied. Here we focus on developing linear models (both simple and multiple) relating a response variable and one or more other variables. Both quantitative and qualitative variables are considered as explanatory variables. Methods for fitting models, model estimation, interpretation, and model diagnostics are also practiced.

Prerequisites: None

Learning Objectives and Outcomes: After the successful completion of the course, the students should be able to analyze relationships among variables for a given situation, using equations or regression models. Once the diagnostic tests are carried out and the model is found to be reasonable, such models may interpret and analyze the data well.

Course Content: Introduction to regression, Correlation, Uses of regression, Simple linear regression model, Parameter estimation, inferences about the model and prediction, Goodness of fit testing, Residual analysis, Multiple regression

Teaching/ Learning Methods: Interactive lectures

Method/s of Evaluation: End-of-semester examination (70%) and assignments (30%)[2 in-class assignments]

Suggested Readings:

- Atkinson, A. C. (1985). *Plots, Transformations, and Regression*. Oxford
- Cook, R.D. & Weisberg, S. (1982) *Residuals and Influence in Regression*, Chapman & Hall.
- Draper, N. R. and Smith, H. (1981) *Applied Regression Analysis*. (2nd ed.). New York: Wiley & Sons.
- Draper, N.R. and Smith, H. (1998). *Applied Regression Analysis*, (3rd ed.). New York: John Wiley & Sons.
- Mead, R. and Curnow, R.N. (1993). *Statistical methods in agriculture and experimental biology*. Chapman & Hall

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Course title: Advanced Marketing Research – [1credits (15L), For IS (core)]

Course code: MS 3002

Rationale: Quantitative methods are widely used in marketing research where inferences provide key insights to companies. MS 3002 provides an understanding of the advanced quantitative and qualitative methodologies of data analysis in marketing research.

Prerequisites: None

Intended Learning Outcomes: After the successful completion of the course, the students should be able to understand the advanced quantitative and qualitative methodologies of data analysis in marketing research, evaluate the options available to analyze data gathered from a marketing research process and apply the data analysis methodologies in a practical scenario.

Course Content: Media Research: Methods of collecting data, Measurements, Media planning, Planning Software, evaluating media schedules (e.g. GRP), Advertising media models, Pricing Research: Types of pricing models (e.g. BPTO), Test Marketing, Simulated Test Marketing, Data Fusion, Application of Multivariate techniques to Marketing (factor, cluster), Application of General Linear Models in Marketing, Conjoint Analysis, Correspondence Analysis

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (80%) and assignments (20%)[2 in-class assignments]

Suggested Readings:

- Lehmann, D. R., Gupta, S., & Steckel, J. H. (2007). *Marketing Research.* Pearson Education
- Stout, G. R., Fox R. J. & Crask, M.(1997). *Marketing Research*. Prentice Hall
- Aakar, D. A. (2011). *Marketing Research* (10th ed.). Wiley

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Course title: Special Topics I (30L, 2C) – [2credits (15L,30P), For IS (optional)]

Course code: IS 3003

Prerequisites: None

Course Content: Selected topics depending on the availability of teaching staff.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: End-of-semester examination (80%) and assignments (20%)[2 in-class assignments]

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Course title: Advanced Topics in Experimental Design – [2credits (30L), For IS (Core)]

Course code : IS 3052

Rationale: If one wants to establish cause and effect relationship in experimentation, one needs to have an experiment statistically designed. [IS 3052 provides an in-depth knowledge on this aspect with industrial applications on several commonly used statistical designs].

Prerequisites: None

Learning Objectives and Outcomes: After the completion of the course, the students should be able to recognize suitable experimental designs for given situations and analyze experimental data.

Course Content: Treatment comparisons; Factorial treatment designs; $\mathbf{2^k}$ and $\mathbf{3^k}$ experiments with examples; Confounding and partial confounding; Fractional replication; Response surface designs; Split plot designs, repeated measure designs.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (70%) and assignments (30%)[2 in-class assignments]

Suggested Readings:

- Montgomery, D. C. (2001). *Design and Analysis of Experiments* (5th ed.). John Wiley &sons
- Kuehl, R. O. (1999). *Design of Experiments: Statistical Principles of Research Design and Analysis* 2nd ed.). Duxbury Press
- Box, G. E. P., Hunter, W. G., & Hunter, J. S. (1978). *Statistics for experiments: An introduction to design, data analysis and model building*. Wiley

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Course title: Data Mining Techniques – [2 Credits (15L 30P), For IS (core)]

Course code: IS 3053

Data Mining is the process of discovering patterns and relationships in large volumes of data, therein has applications in multiple fields of Science. The subject consists of a combination of tools from Statistics, Machine Learning and Database Management that can be used for this process.

Prerequisites: None

Learning Outcomes: Upon the successful completion students should be able to discover the hidden pattern in data and do prediction/classification based on the discovered patterns, by applying the widely used data mining techniques.

Course Content: Introduction to Data Mining(DM); Introduction to a DM software (Matlab); Selected DM Techniques: Neural Networks, Classification & Regression Trees, Support Vector Machines, K-Nearest Neighbours Algorithm, K-means clustering.

Teaching/ Learning Methods: Interactive l**ectures and practical sessions**

Method/s of evaluation: Continues assessments (100%)[3 in-class assignments]

Suggested Readings:

- Kamber, M., & Han, J. (2011). *Data mining: Concepts and Techniques* (3rd ed.). Elsevier
- Larose, D. T., (2005). Discovering knowledge in data: An Introduction to Data Mining. John Wiley and Sons
- Berry, M. J. A., & Linoff, G. S. (2008*). Mastering data mining: The art of science of customer relationship management*. Wiley India Pvt. Limited
- Keedwell, E. & Narayanan, A. (2005). *Intelligent Bioinformatics*. John Wiley & Sons

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Course title: Quality Management/Project Management – [2 Credits (30L), For IS (core)]

Course code: MS 3004

Rationale: To be employed as a statistician or data scientist, the students should possess the managerial skills also such as organizational environment, feasibility analysis, risk management, human resource management etc.. MS 3004 provides those tools with some theoretical knowledge and practical examples.

Prerequisites: None

Intended Learning Outcomes: **Upon successful completion of the course, students should be able to** inspect, manage, control and evaluate the quality of a process. Further students should know about planning, Risk management, Time management, realization, completion, evaluation and transformation of a project.

Course Content: Quality Management: Total Quality Management (TQM) and Quality Management Systems, Tools and Techniques, TQM Through Continuous Improvement, Quality Functions, Economics of quality, Quality management and ethics, Management Role in TQM, Quality Assurance and Quality Cost Analysis; **Project Management:** Phases of the Project Management Life Cycle, Key activities of project close-out , Budgetary considerations Elements of a successful Risk Management Plan, Project reporting tools, Techniques for creating a project plan, Work Breakdown Structure, Network Logic diagram, and Critical Path analysis , Creating a strong project team

Teaching/ Learning Methods: Interactive lectures, problem based learning and group activities

Method/s of evaluation: End of semester examination (70%) and continuous assessments (30%)[at least 1 case study and presentation]

Suggested Readings:

- Evans, J. R., & Lindsay, W. M. (2002). The Management and Control of Quality (5th ed.). South-Western
- Montgomery, D. C. (2008). *Introduction to Statistical Quality Control* (6th ed). Wiley (chapters from 7 to 15)
- Juran, J. M. & Gryna, F. M. (1993*) Quality Planning and Analysis* (1993).
- Goetsch, D. L. & Davis, S. (2006) *Quality Management* (3rd ed.). Prentice Hall

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Course title: Advanced Statistical Modeling –[3credits (45L), For IS(elective)]

Course code: IS 4002

Rationale: Statistical models are useful tools for determining factors or variables which most associates with the behaviour of a process. Complexity of these models increase as the relationship of the variables become non-linear or with the inherent distribution of the response variable deviate from the usual normal distribution and for correlated responses. IS 4002 introduces the theory and application of generalized linear model and mixed models.

Prerequisites: None

Intended Learning Outcomes: At the completion of the course, the students should be able to identify and apply a suitable statistical model for a given dataset. Student should also be able to apply appropriate diagnostics to evaluate the model.

Course Contents: Introduction to statistical modeling; Exponential family of distributions; Generalized linear models: link function, parameter estimation and inferences, hypothesis testing, diagnostics, and adequacy; Logistic regression and over dispersion; multinomial regression; Poisson regression; Mixed models.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (80%) and assignments (20%) [2 in-class assignments]

Suggested Readings:

- Agresti, A. (2003). *Categorical Data Analysis* (2nd ed.). John Wiley & Sons
- Collet, D. (2002). *Modeling Binary Data* (2nd ed.). CRC Press
- McCullah, P. & Nelder, J. A. (1989) *Generalized Linear Models* (2nd ed.). CRC Press
- Aitkin, M., Anderson, D., Francis, B., & Hinde, J.(1989). *Statistical Modelling in GLIM*. Clarendon Press

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Course title: Special Topics II– [2credits (30L), For IS (optional)]

Course code: IS 3003

Prerequisites: None

Course contents: Selected topics depending on the availability of teaching staff.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End-of-semester examination (80%) and assignments (20%)[2 in-class assignments]

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Course title: Risk Management (2C, 30L)

Course code: MS 4007

Rationale: The knowledge on capital markets, financial markets and risks involved in management decisions are key concepts for those who work in industries. This course provides the fundamentals of such topics that are required by the statisticians.

Prerequisites: None

Intended learning outcomes:
Upon successful completion students will be up-to-date with current trends capital markets and risk management and will be able to easily adapt to the corporate environment.

Course content:
Introduction to Capital Markets; Types of financial markets: (debt, equity and derivatives); Introduction to Financial Instruments: (debt, equity and derivatives), Introduction to Time Value of money and interest rates, Risk and Risk aversion, Financial ratios, Portfolio risk, Capital allocation, Market Risk Management, Operational risk, Financial crisis Business case studies and presentations.

Teaching/ Learning Methods: Interactive lectures and problem based learning

Method/s of evaluation: End of semester examination (70%) and continuous assessments (30%) [business case studies and presentation(at least 1 each)]

Suggested Readings :

- Mishkin, F. S., & Eakins, S. G. (2006). *Financial markets and Institutions* (5th ed). Pearson education
- Hull, J. C. (2017). *Options, Futures, and Other Derivatives* (10th ed). Pearson Education

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Course title: Industrial Psychology (2C, 30L)

Course code: MS 4008

Rationale: To be a steady person in the industry, anyone needs some knowledge and skills on organizational behavior, leadership and group behavior skills etc.. This course is designed with the aims of enhancing such skills and career development interfaces for industry personnel.

Prerequisites: None

Intended learning outcomes:
Upon successful completion students will be able to apply concepts of psychology in an industrial context to further their career goals and successful work-life balance.

Course content:
Introduction to Psychology, Organizational Behavior, Leadership & Group Behavior, Psychological Assessments, Work Motivation and Job Designing, Diversity and Issues in Organizations, Psychology of HRM & Ergonomics, Conflicts at Work & Stress, Career Development/Work –Life Interface.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and continuous assessments (30%)[2 in-class assignments]

Suggested Readings :

- Levy, P. (2009). *Industrial/Organizational Psychology* (3rd ed). Worth Publishers

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Course title: Individual Project –[8 credits (240P)]

Course code: ST 4040/ST 4050/ IS 4006

Rationale: Working on a research project gives the opportunity to work closely with a faculty member who is an experienced researcher. The research project, represents the concentration of interests and studies, and possibly, a real contribution to knowledge. It provides an opportunity to learn something new, to improve problem-solving skills and to challenge oneself in new ways.

Prerequisites: None

Intended Learning Outcomes: Upon successful completion of the project, the students will be able to solve real world problems using appropriate theories and techniques learnt throughout the degree program. The students will also be able to extend and develop existing theories to solve complex statistical problems.

Teaching/ Learning Methods: Student centered learning activities and independent learning activities

Method/s of evaluation: Based on thesis and viva (100%)

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Course title: Industrial Training (4C, 120P)

Course code: IS 4005

Prerequisites: None

Rationale: Industrial training provides firsthand experience for the undergraduates to work fulltime in an organization outside the university. The main intention of the programme is to enhance their communication and teamwork skills. They will also be conducting real-time applications using the knowledge they gained at the university while improving their ability to explore new techniques.

Intended learning outcomes:
Upon completion of Industrial Training, the student should be able to integrate classroom theory with workplace practice, develop greater clarity about academic and career goals, recognize administrative functions and company culture, appreciate the ethical basis of professional practice in relevant industry, display a capacity for critical reasoning and independent learning, explore options in career plans and goals.

Course content:

Industrial training provides students to understand and appreciate real-life working experiences. Students may realize their ambition and ascertain their career path from the experience gained during industrial training. The training provides students the opportunity to meet and network with people in the industry, and for the industry the opportunity to identify talents and potential skilled employees.

Teaching/ Learning Methods: Independent learning activities

Method/s of evaluation: 100% based on continuous assessments

- Student Progress & Progress Reports (25 %)
- External supervisor/s (25 %)
- Final Report (25 %)
- Final Presentation (25 %)

Suggested Readings : None

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Courses offered by the Department of Statistics

for Level III and IV

Applied Statistics Theme

Level Three

	Pre Req	Course Unit	Title	Credit	Hours	PS	IS
SI		ST 3007	Operational Research	3	45L	o	
SI	ST 2010	ST 3008	Applied Statistical Models	3	30L 30P	x	x
SI		ST 3009	Applied Time Series	2	30L	x	x
SI		ST 3010	Introduction to Health Statistics	2	15L 30P	o	o
SI	IS 1009/ ST 1011	IS 3001	Sampling Techniques	2	30L	x	x
SI		CS 3008	Introduction to Data Structures & Algorithms	3	30L 30P	x	x
SI		MS 3009	Operational Research II	3	30L 30P		o
SI	CS 1001	IT 3003	Advanced Programming Techniques	3	30L 30P	x	x
SII		ST 3011	Statistical Programming	2	60P	x	x
SII	ST 2008/ MS2001	ST 3012	Statistical Process Control	2	30L	o	o
SII		ST 3013	Essential Mathematics for Statistics	3	45L	x	x
SII		IS 3004	Applied Multivariate Methods	2	30L	x	x
SII		IS 3005	Statistics in Practice I	3	90P	x	x
SII		MS 3004	Quality Management/Project Management	2	30L	o	o
SII		IT 3002	Database Systems	3	30L 30p	x	x

Physical Science- General Degree

Level Three

	Pre Req	Course Unit	Title	Credit	Hours	P1	P2	P3	P4	P5	P6
SI	ST 2006	ST 3006	Regression Analysis	2	30L	o	x	o	x	o	x

SI		ST 3007	Operational Research	3	45L	o	x	o	x	o	x
SI	ST 2006	ST 3009	Applied Time Series	2	30L	o	x	o	x	o	x
SI	ST 1011, ST 2006	IS 3001	Sampling Techniques	2	30L	o	o	o	o	o	o
SII	ST 2008	ST 3012	Statistical Process Control	2	30L	o	o	o	o	o	o

Industrial Statistics- General Degree

Level Three

	Pre Req	Course Unit	Title	Credit	Hours	IS
SI		ST 3006	Regression Analysis	2	30L	x
SI		ST 3009	Applied Time Series	2	30L	o
SI	IS 1009	IS 3001	Sampling Techniques	2	30L	x
SI		MS 3009	Operational Research II	3	30L 30P	x
SII		IS 3004	Applied Multivariate Methods	2	30L	o
SII		IS 3005	Statistics in Practice I	3	60P	o
SII		MS 3004	Quality Management/Project Management	2	30L	o

Course Content - Level III

Course title: Operational Research (3C, 45L)
Course code: ST 3007

Rationale: Managers in any field require to utilize available resources, plan and coordinate activities under many constraints. Operational research techniques can be used to assist such decision-making activities in an optimum way. [ST3007 provides a good foundation about some of the widely used operational research techniques]

Prerequisites: AM 2003

Intended learning outcomes:
Upon successful completion of the course, the students should be able to: describe the fundamental concepts of real world applications in operational research, model decision making problems, obtain solution/s for the formulated model/s using appropriate techniques and software packages.

Course content:
Integer Programming models and solution techniques (Cutting Plane algorithm, Branch-and-Bound algorithm), Zero-one Programming models (mind expanding problems),Transportation models and solution techniques (North-West Corner method, Least Cost method, Vogel's Approximation method, U-V Method), Assignment models and solution techniques(Hungarian method), Inventory Models (Deterministic inventory models with shortages and without shortages),Queuing models (Elements of a queuing model, steady-state measures of performance, single-server models, multiple-server models),Solution techniques using suitable OR packages.

Teaching/ Learning Methods: Interactive lectures and independent learning activities (tutorials)

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%) [2 in-class assignments]

Suggested Readings :

- Taha, H. A. (2016). *Operational Research: An Introduction* (10th ed.). Pearson
- Verma, A. P. (2009). *Operations Research* (3rd ed). S. K. Kataria & Sons
- Panneerselvam, R. (2006) *Operations Research* (2nd ed.). PHI Learning Pvt. Ltd.
- Wagner, H. M. (1975). *Principles of Operations Research* (2nd ed.). Prentice Hall
- Hillier, F. S., & Lieberman, G. J. (2001). *Introduction to operations research* (7th ed). McGraw-Hill

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Course title: Applied Statistical Models (3C, 30L 30P)

Course code: ST 3008

Rationale: Statistical models describe a response variable as a function of one or more predictor variables. The response variable can have any type of distribution for examples, normal, binomial, Poisson etc. The predictors can be either categorical or continuous also random effects or fixed effects. ST 3008 provides some theoretical foundation and thorough practical knowledge on regression, GLMs, nonlinear models and mixed effects models.

Prerequisites: ST 2010

Intended learning outcomes:
After successful completion of the course the student should be able to analyze and interpret categorical and continuous data using appropriate linear and non-linear models using SAS/R. The student should also be able to use appropriate model diagnostic tools to validate the fitted models.

Course content:
Introduction to modeling. Continuous models with fixed effects: Simple Linear Regression, Multiple Linear Regression, Non Linear Regression. Data categorization. Contingency table analysis. Categorical models with fixed effects: log linear models, logistic models, Polytomous regression, Ordinal response models, Nominal response models, Analysis of categorical data using a SAS/R, Interpreting parameter estimates, Goodness of fit test. Introduction to random effects and mixed models.

Teaching/ Learning Methods: Interactive lectures, practical sessions group activities

Method/s of evaluation: End of semester examination (70%), Continuous assessment (20%)[2 in-class assignemnts] and Case studies/ Group project (10%)

Suggested Readings :

- Chatterjee, S., & Hadi*, A*. S. (2006). *Regression Analysis by Example* (4th ed.). John Wiley & Sons
- Agresti, A. (2003). *Categorical Data Analysis* (2nd ed.). John Wiley & Sons
- Dobson, A.J., & Barnett, A. (2008). *An introduction to Generalized Linear Models* (3rd ed.). Taylor & Francis
- Brown, H., & Prescott, R. (2015). *Applied Mixed Models in Medicine* (3rd ed.). John Wiley & Sons
- Collet, D. (2002). *Modeling Binary Data* (2nd ed.). CRC Press

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Course title: Applied Time Series (2C, 30L)

Course code: ST 3009

Rationale: Most of the real-life processes are time related. This course is designed to provide students univariate time series techniques and models in an applied setting.

Prerequisites: ST 2006

Intended learning outcomes:
After successful completion of the course the student should be able to use appropriate univariate time series models for forecasting.

Course content:
Introduction: Areas of application, Objectives of time series analysis, Components of time series, Descriptive analysis. Distributional properties: Independence, Autocorrelation, Stationary. Probability models to time series: Random walk, Autoregressive model. Moving Average model, mixed models, parameter estimation, Diagnostics. Forecasting: Optimal forecasts, Forecasts for ARMA models, Exponential Smoothing forecasting method.

Teaching/ Learning Methods: Interactive lectures and independent learning activities

Method/s of evaluation: End of semester examination (80%) and Continuous assessment (20%) [2 in-class assignments]

Suggested Readings :

- Makridakis, S. G., Hyndman, R. J., & Wheelwright, S. C. (1998). *Forecasting: Methods and Applications* (3rd ed.). Wiley
- Chatfield, C. (2016). *The Analysis of Time Series: An Introduction* (6th ed.). CRC Press
- Box, G. E. P., Jenkins, G. M., Reinsell, G. C., & Ljung, G. M. (2015). *Time Series Analysis: Forecasting and Control* (5th ed.). Wiley

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Course title: Introduction to Health Statistics (2C, 15L 30P)

Course code: ST 3010

Rationale: Analysis of health data uses specialized descriptive and inferential techniques for evaluating the health status of a population of interest. [ST 3010 provides theory and application of essential statistics for the analysis of health data]
Prerequisites: None

Intended learning outcomes:
At the end of the course the students should be able to define and compute official health statistics and construct life tables. Compute suitable descriptive statistics. Construct confidence intervals. Carryout hypothesis tests, calculate sample sizes. Identify Data Science approaches to health data. Analyze and interpret health data using statistical package/s.

Course content:
Introduction to official health Statistics: Mortality, Crude death rate, Standardization, Morbidity, Incidence and prevalence. Introduction to Life tables and applications. Descriptive statistical methods for health data (Summary statistics), Inferential methods (confidence intervals, hypothesis testing) for health data, Sample size calculation. Introduction to Data science for health statistics. Health data analysis using statistical packages.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: End of semester examination (70%) and Continuous assessment [minimum of 2 In-class assignments and Case studies] (30%)

Suggested Readings :

- Armitage, P., Berry, G., & Mathews, J. N. S. (2004). *Statistical Methods in Medical Research* (4th ed.). John Wiley & Sons
- Altman, D.G. (1990). *Practical Statistics for Medical Research*. CRC Press
- Bland, J. M. (2015). *An Introduction to medical statistics* (3rd ed.). Oxford University Press
- *Marasinghe,* M. G., & Kennedy, W. J. (2008). *SAS for Data Analysis*. Springer Science & Business Media

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Course title: Statistical Programming (2C, 60P)

Course code: ST 3011

Rationale: The ability to find trends in data, visualize and model it, using mathematical and statistical methods is increasingly useful with the recent abundance of data collected. To analyze such data in large volumes, a basic understanding of programming is imperative. ST 3011 provides the foundational programming skills and best practices required to explore, model and visualize various types of data to solve business problems.

Prerequisites: None

Intended learning outcomes:
After a successful completion a student should be able to plot 2D and 3D graphs using Python /R; write Python/R functions to solve statistical problems ; perform data analysis using Python /R

Course content:
Introduction to Python. Built-in data types, Arrays and Matrices, Basic Math using Python. Basic functions and Numerical indexing, Special arrays. Advanced selection and Assignment, Flow control, loops and exception handling. Graphics using Python. Introduction to R; Data Management, Descriptive Analysis, Writing functions in R; Statistical Inference.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: Continuous assessments [At least 5 lab assignments] (100%)

Suggested Readings :

- Venables, W. N., D.M. Smith, D. M., & the R Core Team (2009). *An Introduction to R: A Programming Environment for Data Analysis and Graphics* (2nd ed). Network Theory

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Course title: Statistical Process Control (2C, 30L)

Course code: ST 3012

Rationale: Cumulative sum (CUSUM) and exponentially weighted moving average (EWMA) Control Charts are capable of detecting small shifts in process parameters, leading to more effective process monitoring, as opposed to traditional Shewhart's control charts which misjudge the occurrence of small process shifts. When there is more than one process parameter, to detect shifts in these, Multivariate Control Charts are used. In addition to these Control Charts capability analysis, acceptance sampling schemes and process optimization techniques will also be discussed.

Prerequisites: ST 2008/ MS2001

Intended learning outcomes:
Upon successful completion of the course the student should be able to investigate and analyze process capability, advanced charts and control charts for correlated data. The student should also be able to recognize the statistical quality control methods using acceptance sampling, response surface approach for optimizing the process.

Course content:
Capability analysis; Cumulative Sum (CUSUM) control charts; Exponentially Weighted Moving Average (EWMA) Charts; Acceptance sampling: double, sequential, multiple; Decision theory approach; Multivariate control charts; Process optimization with design experiment.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (80%) and Continuous assessment (20%) [2 in-class assignments]

Suggested Readings :

- Montgomery, D. C. (2008). *Introduction to Statistical Quality Control* (6th ed). Wiley
- Duncan, A. J. (1986). *Quality Control and Industrial Statistics* (5th ed.). Irwin

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Course title: Essential Mathematics for Statistics (3C, 45L)

Course code: ST 3013

Rationale: Mathematical theories such as linear algebra, matrices, calculus etc. are required for proves of most of the higher level statistical theories. ST 3013 provides those tools for students with required amount of theoretical knowledge.

Prerequisites: None

Intended learning outcomes:
Upon the successful completion of the course the students should be able to apply basic mathematical tools in solving theoretical and practical problems in Statistics.

Course content:

Linear algebra: Linear dependence, rank and the solution of homogeneous equations, characteristic polynomials, eigenvalues , eigenvectors, spectral theorem for symmetric matrices, idempotent matrices and properties, orthogonal projections, trace of a matrix and properties, positive definite/semi definite matrices, quadratic forms, differential calculus in matrix notation, direct product (kronecker) of any two matrices, generalized inverse /conditional inverse; Caculus1: Concepts of functions, limits and continuity, L'Hopital's rule, the fundamental theorem of calculus, approximation of definite integrals, Improper integrals; Series and Sequences: sequences and their convergence, series and convergence of series, power series and their convergence of radius, Taylor series and their application; Several variable calculus: functions of several variables, continuity, differentiability, derivatives, multiple integrals, change of variables

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%)[2 in-class assignments]

Suggested Readings :

- Kaplan, W., & Lewis, D. J. (1970). *Calculus and Linear Algebra*: *Vectors in the Plane and One-Variable Calculus*. Wiley
- Axler, S. (2014). *Linear Algebra Done Right* (3rd ed.). Springer
- Larson, R., & Edwards, B. H. (2009). *Calculus* (9th ed.). Cengage Learning

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Course title: Sampling Techniques (2C, 30L)

Course code: IS 3001

Rationale: This course concentrates on the statistical aspects of taking and analyzing a sample. It gives guidance on how to how to design and analyze many different forms of sample surveys. [IS 3001 provides a good theoretical as well as practical foundation for sampling techniques used in practice]

Prerequisites: IS 1009/ST 1011, ST 2006

Intended learning outcomes:
Upon the successful completion of the course the students should be able to identify and effectively use the theory behind sampling techniques that are commonly used in statistics.

Course content:
Simple Random Sampling (SRS), Sample size determination, Ratio and Regression estimators under SRS, Stratified, Systematic, and Quota sampling. Separate and combined estimators for stratified sampling. Cluster sampling, Multi-stage sampling, Complex sample designs and related issues.

Teaching/ Learning Methods: Interactive lectures, group activities

Method/s of evaluation: End of semester examination (70%) and Continuous assessments [at least 1 in-class assignment] & group project [at least 1] (30%)

Suggested Readings :

- Thompson, S. K. (2002). *Sampling* (2nd ed.). John Wiley & Sons
- Som, R. K. (1995). *Practical sampling Techniques* (2nd ed.). CRC Press
- Rao, P. S. R. S., & Myron J. Katzoff, M. J. (2010). *Hand book of Sampling Techniques and Analysis* (1st ed.). CRC Press

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Course title: Applied Multivariate Methods (2C, 30L)

Course code: IS 3004

Rationale: In real life, many processes are affected by the actions of not only one variable but several variables simultaneously. Multivariate analysis is a natural tool to analyze several variables (possibly correlated) at the same time to have insight of the combined effect, if any. This course provides some theoretical background as well as a good practical foundation for commonly used multivariate techniques.

Prerequisites: ST 2006

Intended learning outcomes:
Upon successful completion of this course the students should be able to apply the related multivariate techniques to data with multiple measurements satisfying the underlying theories and assumptions. The students should also be able to demonstrate basic computer skills in analyzing such data with the help of appropriate statistical packages.

Course content:
Overview, examples and introduction. multivariate normal distribution ; mean vector and variance covariance matrix, correlation matrix; bivariate normal distribution and density, missing values and outliers, summary statistics, standardized data; sample correlations; multivariate data plots, checking for multivariate normality; eigen-values and eigenvectors; geometric descriptions; principal components analysis, factor analysis, discriminant analysis, cluster analysis; multivariate inference; inference for one and two independent samples, profile analysis, repeated measurements, manova, canonical variates analysis, canonical correlations.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%) [2 in-class assignments]

Suggested Readings :

- Johnson, D. E. (1998). *Applied Multivariate Methods for Data Analysts* (1st ed.). Duxbury Press
- Johnson, R. A., & Wichern, D. W. (2013*). Applied Multivariate Statistical Analysis* (3rd ed.). Pearson Education Limited
- Afifi, A., May, S., & Clark, V. A. (2003). *Computer Aided Multivariate Analysis* (4th ed.). CRC Press

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Course title: Statistics in Practice I (3C, 90P)
Course code: IS 3005
Rationale: To be employed as a Statistician, a Data Analyst or a Data Scientist, apart from the technical and theoretical knowledge, one should possess and acquire skills to solve real world problems and communicate findings effectively. Through this module, such exposure is provided in a class room environment.
Prerequisites: None

Intended learning outcomes:
After the successful completion of this course, a student should be able to employ the complex process of problem-solving a massing various areas in the field of statistics. Students should be able to formulate the problems, improve on report-writing and research skills, their communication, personnel and business skills.

Course content:
This course deals with general principles involved with statistical methods covered levels I, II in solving real-life statistical problems.

Teaching/ Learning Methods: Problem based learning, group activities and independent learning activities

Method/s of evaluation: Continuous assessments (95%) and attendance (5%)

Attendance	5%
Presentations on topics	10%
Inclass - test on Data Analysis	15%
Case Study 1	10%
Case Study 2	5%
Inclass - test on statistical modelling	15%
Writing News paper article	5%
Interim workshop participation	5%
Industry group Project	30%

Suggested Readings :

- Chatfield, C. (1995). *Problem Solving: A Statistician's Guide* (2nd ed.). CRC Press

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Course title: Quality Management/Project Management (2C, 30L)

Course code: MS 3004

Rationale: To be employed as a statistician or data scientist, the students should possess the managerial skills also such as organizational environment, feasibility analysis, risk management, human resource management etc.. MS 3004 provides those tools with some theoretical knowledge and practical examples.

Prerequisites: None

Intended learning outcomes:
Upon successful completion of the course students should be able to apply key theoretical concepts on quality control and project management practiced by the corporate world.

Course content:
Quality Management: Macro and Micro organizational Environment (PESTEL, Resource Based View)Market Analysis(Porter's Five Forces Analysis, SWOT Analysis) Project Feasibility Analysis (Johnson & Schole's SFA Framework) Stakeholder Analysis, Organizational Change Management; Project Management: Project Selection, Approach Selection, The Work Breakdown Structure, The Network Diagram, Cost Effort Estimation, Optimizing the Network, Gantt Chart, Risk Management, Cost Estimation, Contract Management, Productivity Improvement, Project Management Steps, Making the Budget, Project Monitoring and Control, Human Resource Management, Project Termination.

Teaching/ Learning Methods: Interactive lectures, problem based learning and group activities

Method/s of evaluation: End of semester examination (70%) and continuous assessments (30%)[at least 1 case study and presentation]

Suggested Readings :

- Heagney, J. (2016). *Fundamentals of Project Management*. AMACOM

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Course title: Operational Research II (3C, 30L 30P)

Course code: MS 3009

Rationale: Mangers in any field require to utilize available resources, plan and coordinate activities under many constraints. Operational research techniques can be used to assist such decision making activities in an optimum way. [MS3009 is a continuation of MS1003 that extends the theoretical and practical knowledge on operational research techniques]

Prerequisites: MS 1003

Intended learning outcomes:
Upon successful completion of the course, the students should be able to describe the fundamental concepts of real world applications in operational research, model decision making problems, obtain solution/s for the formulated model/s using appropriate techniques and software packages.

Course content:
Network Models (Minimal Spanning Tree algorithm, algorithms for Shortest-Route problem, Maximal Flow model), Project Planning (Critical Path Method, Programming Evaluation and Review Technique), Inventory Models (Deterministic inventory models with shortages and without shortages, Probabilistic Inventory models), Queuing models (Elements of a queuing model, steady-state measures of performance, single-server models, multiple-server models), Solution techniques using suitable OR packages.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: End of semester examination (70%) and Continuous assessment (30%) [at least 2 in-class assignments]

Suggested Readings :

- Taha, H. A. (2016). *Operational Research: An Introduction* (10th ed.). Pearson
- Verma, A. P. (2009). *Operations Research* (3rd ed). S. K. Kataria & Sons
- Panneerselvam, R. (2006) *Operations Research* (2nd ed.). PHI Learning Pvt. Ltd.
- Wagner, H. M. (1975). *Principles of Operations Research* (2nd ed.). Prentice Hall
- Hillier, F. S., & Lieberman, G. J. (2001). *Introduction to operations research* (7th ed). McGraw-Hill

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Applied Statistics Theme

Level Four

	Pre Req	Course Unit	Title	Credit	Hours	PS	IS
SI		ST 4011	Econometrics	2	30L	x	x
SI	CS 3008	ST 4035	Data Science	3	30L 30P	x	x
SI		ST 4036	Time to Event Analysis	2	30L	x	x
SI	ST 3010	ST 4037	Epidemiology	2	30L	o	o
SI		IS 4007	Statistics in Practice II	3	90P	x	x
SI		MS 4007	Risk Management	2	30L	o	o
SI		MS 4008	Industrial Psychology	2	30L	x	x
SI		IT 4004	Advance Database Systems	3	30L 30P	x	x
SI	CS 2002	IT 4005	Advanced Software Engineering	3	30L 30P	o	o
SII		IS 4009	Industrial Training	6	180P	x	x
SII		IS 4010	Industrial Research Project	6	180P	x	x

Course Content - Level IV

Course title: Econometrics (2C, 30L)

Course code: ST 4011

Rationale: Analysis of economic and financial data requires the formulation a unique methodological framework. ST 4011 provides the theoretical as well as a practical foundation for the students to analyze and make accurate projections of economic and financial data.

Prerequisites: ST 3008, ST 3009

Intended learning outcomes:
Upon successful completion the students will be able to apply statistical methods in the context of economics and carry out a successful econometric analysis.

Course content:
The application of linear regression model and the interpretations of properties of least squares estimates in the context of economic theory, an introduction to violations of OLS assumptions in economics, Simultaneous equations, Time Series Econometrics, Case studies.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and continuous assessment [at least 2 in-class assignments] (30%)

Suggested Readings :

- Gujarati, D. N. (2009). *Basic Econometrics* (5th ed). McGraw Hill

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Course title: Data Science (3C, 30L 30P)

Course code: ST 4035

Rationale: Data science is an interdisciplinary field that uses scientific techniques and algorithms to extract information from data. The course is designed to provide students in depth knowledge of data analysis techniques in data science.

Prerequisites: ST 3011, ST 3013, CS 3008

Intended learning outcomes:
After a successful completion a student should be able to apply basic techniques of Data Science for decision making.

Course content:
Introduction; Ethics; Data Wrangling & Pre-processing; How to deal with large data sets: Parallel computing, Map reduce framework – Hadoop; Data Communication & Visualization; Statistical Methods: Regression, Logistic Regression, Random Forest, Support Vector Machines; Machine Learning Algorithms.

Teaching/ Learning Methods: Interactive lectures and practical sessions

Method/s of evaluation: End of semester examination (50%) and **c**ontinuous assessments (50%) [at least 2 In-class assignments and 1 group project]

Suggested Readings :

- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2014). *An Introduction to Statistical Learning: With Applications in R.* Springer New York
- Hastie, T., Tibshirani, R., & Friedman, J. (2009). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction* (2nd ed). Springer
- Leskovec, J., Rajaraman, A., & Ullman, J. (2014). *Mining Massive Data Sets* (2nd ed). Cambridge University Press
- Provost, F., & Fawcett, T. (2013). *Data Science for Business: What you need to know about data mining and data-analytic thinking* (2nd ed). O'Reilly Media

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Course title: Time to Event Analysis (2C, 30L)

Course code: ST 4036

Rationale: Analysis of duration data is complicated due to the presence of censored observations arising from the non-occurred events in the data. Therefore, specialized methods of analysis are available for analysing such duration data. [ST 4036 provides a fundamental theoretical foundation as well practical foundation on statistical methods for analysing duration data].

Prerequisites: ST 2006

Intended learning outcomes:
At the end of the course the students should be able to explain characteristics of time to event data. Identify suitable distributions for time to event data. Describe time to event data using suitable parametric and non-parametric measures. Analyze time to event data using parametric models and non-parametric regression models. Calculate sample sizes. Analyze and interpret time to event data using statistical package/s.

Course content:
Characteristics of time to event data, Distributions for time to event data, Non-parametric methods, Parametric regression, Hazard regression, Power analysis and sample size calculation, fitting parametric and semi parametric models, analysis of time to event data using SAS/R.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and continuous assessment (30%)[2 in-class assignments]

Suggested Readings :

- Hosmer, D.W., Lemeshow S., & May, S. (2011). *Regression modeling of time to event data* (2nd ed). John Wiley & Sons
- Collet, D. (2015). *Modeling Survival Data in Medical Research* (3rd ed). CRC Press
- Cox, D. R., & Oakes, D. (1984). *Survival Analysis* .Chapman & Hall

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Course title: Epidemiology (2C, 30L)

Course code: ST 4037

Rationale: Statistics is essential in Epidemiology which studies the distribution of diseases and risk factors for diseases in human populations. Therefore, it is important for students to be able to identify best study designs, statistical analysis and ethics in Epidemiological studies. ST 4037 provides essential theory and application of statistical concepts and ethics in epidemiology.

Prerequisites: ST 3010

Intended learning outcomes:
At the end of the course the students should be able to describe basic designs for epidemiological studies. Compute relative risk and odds ratio. Identify confounding and interaction. Fit suitable models for epidemiological data using SAS/R. Perform bioassay. Plot and interpret ROC curve for epidemiological data. Identify ethics in health data analysis.

Course content:
Introduction to epidemiology. Basic Epidemiological designs: surveys, cohort studies, case control studies. Relative risk and odds ratio. Confounding and interaction. Modeling epidemiological data using SAS/R: logistic regression and other models. Bioassay. ROC analysis. Ethics in health data analysis.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (80%) and Continuous assessment (20%) [2 in-class assignments]

Suggested Readings :

- Schlesselman, J.J. (1982). *Case control studies: Design, Conduct, Analysis*. Oxford University Press
- Collet, D. (1991). *Modeling binary data* (2nd ed). Taylor & Francis
- Woodward, M. (2014). *Epidemiology* (3rd ed). CRC Press

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Course title: Statistics in Practice II (3C, 90P)
Course code: IS 4007
Rationale: Continuing the experience acquired in a class room environment on skills required for employment through IS3005, the students are trained to work at a higher level in terms of solving complex problems through consultancies, and expose them to the management level of the industry, grooming them to be better employable.

Prerequisites: None

Intended learning outcomes:
After the successful completion of this course, a student should be able solve real-world problems currently faced by the industry by using various areas in the field of statistics. Students should also be able to communicate the findings to the industry in both oral and written form.

Course content:
This course deals with general principles involved with statistical methods covered levels I, II and III in solving real-life statistical problems. It is aimed at students who have exposure to these areas but are unsure what to do when faced with real data, especially if the data are 'messy' or the objectives are unclear.

Teaching/ Learning Methods: Problem based learning, group activities and independent learning activities

Method/s of evaluation: Continuous assessments (95%) and attendance (5%)

Attendance	5%
Case study on exploratory Data Visaulization	10%
Presentations on Statiscal Topics (Learning the topic)	5%
Inclass (on 10 topics)	10%
Case Study based on Excel	10%
Case Study on Data Analysis	10%
Laboratory Based test on Data Analysis	20%
Industry Project (Group)	30%

Suggested Readings :

- Chatfield, C. (1995). *Problem Solving: A Statistician's Guide* (2nd ed). Chapman & Hall

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Course title: Risk Management (2C, 30L)

Course code: MS 4007

Rationale: The knowledge on capital markets, financial markets and risks involved in management decisions are key concepts for those who work in industries. This course provides the fundamentals of such topics that are required by the statisticians.

Prerequisites: None

Intended learning outcomes:
Upon successful completion students will be up-to-date with current trends capital markets and risk management and will be able to easily adapt to the corporate environment.

Course content:
Introduction to Capital Markets; Types of financial markets: (debt, equity and derivatives); Introduction to Financial Instruments: (debt, equity and derivatives), Introduction to Time Value of money and interest rates, Risk and Risk aversion, Financial ratios, Portfolio risk, Capital allocation, Market Risk Management, Operational risk, Financial crisis Business case studies and presentations.

Teaching/ Learning Methods: Interactive lectures and problem based learning

Method/s of evaluation: End of semester examination (70%) and continuous assessments (30%) [business case studies and presentation(at least 1 each)]

Suggested Readings :

- Mishkin, F. S., & Eakins, S. G. (2006). *Financial markets and Institutions* (5th ed). Pearson education
- Hull, J. C. (2017). *Options, Futures, and Other Derivatives* (10th ed). Pearson Education

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Course title: Industrial Psychology (2C, 30L)

Course code: MS 4008

Rationale: To be a steady person in the industry, anyone needs some knowledge and skills on organizational behavior, leadership and group behavior skills etc.. This course is designed with the aims of enhancing such skills and career development interfaces for industry personnel.

Prerequisites: None

Intended learning outcomes:
Upon successful completion students will be able to apply concepts of psychology in an industrial context to further their career goals and successful work-life balance.

Course content:
Introduction to Psychology, Organizational Behavior, Leadership & Group Behavior, Psychological Assessments, Work Motivation and Job Designing, Diversity and Issues in Organizations, Psychology of HRM & Ergonomics, Conflicts at Work & Stress, Career Development/Work –Life Interface.

Teaching/ Learning Methods: Interactive lectures

Method/s of evaluation: End of semester examination (70%) and continuous assessments (30%)[2 in-class assignments]

Suggested Readings :

- Levy, P. (2009). *Industrial/Organizational Psychology* (3rd ed). Worth Publishers

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Course title: Industrial Training(6C, 180P)

Course code: IS 4009

Prerequisites: None

Rationale: Industrial Training provides necessary experience for a graduate to be better employed. In a field related to "Applied Statistics", being an intern gives an opportunity to experience what problems are being solved in the industry, while also acquiring necessary skills to work to meet targets, communicating and liaising with other industry personnel in a professional manner.

Intended learning outcomes:
Upon completion of Industrial Training, the student should be able to integrate classroom theory with workplace practice, develop greater clarity about academic and career goals, recognize administrative functions and company culture, appreciate the ethical basis of professional practice in relevant industry, display a capacity for critical reasoning and independent learning, explore options in career plans and goals.

Course content:
Industrial training provides students to understand and appreciate real-life working experiences. Students may realize their ambition and ascertain their career path from the experience gained during industrial training. The training provides students the opportunity to meet and network with people in the industry, and for the industry the opportunity to identify talents and potential skilled employees.

Teaching/ Learning Methods: Independent learning activities

Method/s of evaluation: 100% based on

- Attendance - Academic Mentor's Meetings – (10%)
- Academic Mentor's progressive evaluation through log book and progress reports (FORM A & FORM B) - (25%)
- Industry Mentor's Evaluation on the training – (FORM C) **-** (25%)
- Final Presentation and Viva– Mark from a panel of 3 members - (20 %)
- Collection of progress reports - minimum 8 progress reports - (20%)

Suggested Readings :

- None.

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Course title: Industry Research Project – (6C, 180P)

Course code: IS 4010

Rationale: Working on an industrial research project gives the opportunity to work closely with a faculty member who is an experienced researcher and also an industry personnel who is an expert in the industrial related to the field. The industrial research project, represents the concentration of interests and studies, and possibly, a real contribution to knowledge. It provides an opportunity to improve problem-solving skills and to challenge oneself in new ways.

Prerequisites: None

Intended Learning Outcomes: Upon successful completion of the industrial project, the students will be able to solve real world problems using appropriate theories and techniques learnt throughout the degree program.

Course content:
Students will be allocated to solve an industrial based problem using statistical/ computational techniques and they are expected to work independently to solve it.

Teaching/ Learning Methods: Student centered learning activities

Method/s of evaluation: 100% based on,

- Industry Research Report– Marks from the Academic Mentor (15%) + Industry Mentor (15%) – FORM D - (30%)
- Industry Research Report – Mark from examiner - (50%)
- Presentation/VIVA Examination – Panel of Examiners - (20%)

Suggested Readings :

- Statistics textbooks related to the research project