PANJAB UNIVERSITY, CHANDIGARH-160014 (INDIA)
(Estd. under the Panjab University Act VII of 1947—enacted by the Govt. of India)

FACULTY OF SCIENCE

SYLLABUS

FOR

M.Sc. STATISTICS (Semester System)
Examinations, 2012-2013

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APPLICABILITY OF REGULATIONS FOR THE
TIME BEING IN FORCE

Notwithstanding the integrated nature of a course spread over more than one academic
year, the regulations in force at the time a student joins a course shall hold good only for the
examinations held during or at the end of the academic year. Nothing in these regulations
shall be deemed to debar the University from amending the regulations subsequently and the
amended regulations, if any, shall apply to all students whether old or new.

Note:

A candidate for M.A. examination shall offer Psychology or Sociology or Statistics or
Public Administration only if he/she has completed the prescribed courses in an
affiliated college or the Department concerned of this University.
GUIDELINES FOR CONTINUOUS INTERNAL ASSESSMENT (20%) FOR REGULAR STUDENTS OF POST-GRADUATE COURSES of M.Sc. Statistics (Semester System)

(Effective from the First Year Admissions for the Academic Session 2005-2006)

1. The Syndicate has approved the following guidelines, mode of testing and evaluation including Continuous Internal Assessment of students:
   (i) Terminal Evaluation  :  80 
   (ii) Continuous Assessment  :  20 
   (iii) Continuous Assessment may include written assignment, snap tests, participation in discussions in the class, term papers, attendance etc.
   (iv) In order to incorporate an element of Continuous Internal Assessment of students, the Colleges/Departments will conduct one written test as quantified below :

   (a) Written Test  :  25 (reduced to 5)
   (b) Snap Test  :  25 (reduced to 5)
   (c) Participation in Class Discussion  :  15 (reduced to 3)
   (d) Term Paper  :  25 (reduced to 5)
   (e) Attendance  :  10 (reduced to 2)

   Total :  100 reduced to 20

2. Weightage of 2 marks for attendance component out of 20 marks for Continuous Assessment shall be available only to those students who attend 75% and more of classroom lectures/seminars/workshops. The break-up of marks for attendance component for theory papers shall be as under :

   Attendance Component   Mark/s for Theory Papers
   (a) 75 % and above upto 85 %  :  1
   (b) Above 85 %  :  2

3. It shall not be compulsory to pass in Continuous Internal Assessment. Thus, whatever marks are secured by a student out of 20% marks, will be carried forward and added to his/her score out of 80%, i.e. the remaining marks allocated to the particular subject and, thus, he/she shall have to secure pass marks both in the University examinations as well as total of Internal Continuous Assessment and University examinations.

4. Continuous Internal Assessment awards from the affiliated Colleges/Departments must be sent to the Controller of Examinations, by name, two weeks before the commencement of the particular examination on the proforma obtainable from the Examination Branch.

SPECIAL NOTES :
   (i) The theory paper will be of 80 marks and 20 marks will be for internal assessment.
   (ii) For the private candidates, who have not been assessed earlier for internal assessment, the marks secured by them in theory paper will proportionately be increased to maximum marks of the paper in lieu of internal assessment.
   (iii) The paper setter must put note (ii) in the question paper.
   (iv) In the case of Postgraduate Courses in the Faculties of Arts, Science, Languages, Education, Design & Fine Arts, and Business Management & Commerce, falling under the purview of Academic Council, where such a provision of Internal Assessment/Continuous Assessment already exists, the same will continue as before.
   (iv) The marks obtained by a candidate in Continuous Internal Assessment in Postgraduate Classes from the admissions of 2004 will be shown separately in the Detailed-Marks-Card (D.M.C.).

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Outlines of Text, Syllabi and Courses of Reading in the Subject of Statistics for M.Sc. (Statistics)  
I-IV semester for the session 2012-13 i.e., 1st & 3rd Semesters November/December 2012 and 2nd & 4th Semesters April/May 2013 Examinations, respectively.

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Semester-I</td>
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<tr>
<td>Stat-101</td>
<td>Linear Algebra</td>
<td>4</td>
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<tr>
<td>Stat-102</td>
<td>Distribution Theory</td>
<td>4</td>
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<tr>
<td>Stat-103</td>
<td>Statistical Methods with Packages</td>
<td>4</td>
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<td></td>
<td>(Theory ¾, Practical ¼)</td>
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<tr>
<td>Stat-104</td>
<td>Course selected from module</td>
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<tr>
<td>Semester-II</td>
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<tr>
<td>Stat-201</td>
<td>Statistical Computing using FORTRAN</td>
<td>4</td>
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<td>(Theory ½, Practical ½)</td>
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<tr>
<td>Stat-202</td>
<td>Estimation and Testing of Hypotheses</td>
<td>4</td>
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<td>(Theory ¾, Practical ¼)</td>
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<tr>
<td>Stat-203</td>
<td>Sampling Theory and Official Statistics</td>
<td>4</td>
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<td>(Theory ¾, Practical ¼)</td>
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<tr>
<td>Stat-204</td>
<td>Course selected from module</td>
<td>4</td>
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<tr>
<td>Semester-III</td>
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<tr>
<td>Stat-301</td>
<td>Nonparametric Inference</td>
<td>4</td>
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<td>(Theory ¾, Practical ¼)</td>
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<tr>
<td>Stat-302</td>
<td>Statistical Process and Quality Control</td>
<td>4</td>
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<td>(Theory ¾, Practical ¼)</td>
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<tr>
<td>Stat-303</td>
<td>Linear Inference</td>
<td>4</td>
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<td>(Theory ¾, Practical ¼)</td>
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<td>Stat-304</td>
<td>Course selected from module</td>
<td>4</td>
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<tr>
<td>Semester-IV</td>
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<tr>
<td>Stat-401</td>
<td>Multivariate Analysis</td>
<td>4</td>
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<td></td>
<td>(Theory ¾, Practical ¼)</td>
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<tr>
<td>Stat-402</td>
<td>Design and Analysis of Experiments</td>
<td>4</td>
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<td></td>
<td>(Theory ¾, Practical ¼)</td>
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<td>Stat-403</td>
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<tr>
<td>Stat-404</td>
<td>Course selected from module</td>
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MODULE

M 1  Actuarial Statistics  4
M 2  Categorical Data Analysis  4
M 3  Econometrics  4
M 4  Economic Statistics  4
M 5  Advanced Inference  4
M 6  Measure and Probability Theory  4
M 7  Operations Research  4
M 8  Real and Complex Analysis  4
M 9  Reliability  4
M 10  Simultaneous Inference  4
M 11  Statistical Simulation and Computation  4
M 12  Stochastic Processes  4
M 13  Survival Analysis  4

ANY OTHER COURSE WHICH THE BOARD OF CONTROL MAY DECIDE TO OFFER.
NOTES:

1. The Board of Control shall decide which papers from the selected modules shall be offered in M.Sc. (Statistics) 1st, 2nd, 3rd and 4th Semesters.

2. Each paper/course of 4 credits shall carry hundred marks.

3. A student shall be required to earn a total of 64 credits to become eligible for the award of M.Sc. (Statistics) degree.

4. For a uniform spread of the syllabus over four semesters, a student shall be required to attend classes for courses amounting to a minimum of 12 credits and a maximum of 20 credits each semester in the four-semesters M.Sc. (Statistics) programme.

5. The composition, duration and the general style of the theory papers in the final examination in each semester will be decided upon by the Board of Control.

6. The mode of conduct of practical examinations in each semester will be decided upon by the Board of Control.

7. In the final examination of the course, which is divided into theory and practical parts, the distribution of the weightage for the practical part will be as follows:
   
   (a) Practical questions (3/5)
   (b) Viva-voce (1/5)
   (c) Record of practicals (1/5)

8. The practical marks in course Stat-202: Statistical Computing using FORTRAN will be based entirely on Internal Assessment.

9. The marks in courses M 11 Statistical Simulation & Computation will be based entirely on Internal Assessment.

10. In the final examination of the course, which is divided into theory and practical parts, the theory and practical Papers will be treated as independent units for passing in a paper.

11. Evaluation to the extent of 20% of the theory marks in each course will be based on Internal Assessment. The Board of Control will decide mode of Internal Assessment.
DETAILS OF TEXT AND SYLLABI

SEMESTER-I

Stat-101: LINEAR ALGEBRA

Final Examination : 80 Marks
Internal Assessment : 20 Marks

Objective : Techniques of linear algebra useful in various Statistics courses will be covered in this course. After learning this course, the students will be well equipped to apply these techniques in many major Statistics courses like Linear Inference, Multivariate Analysis and Operations Research etc.

Note :- The question paper will consist of eight questions carrying equal marks. A candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

Review of basic Notions of Vector Spaces; Subspaces.


Linear Transformations: Kernel and range, inverse transformations, matrices of linear transformations. Change of basis, similarity.


Eigenvalues and Eigenvectors : Cayley Hamilton Theorem, diagonalization, triagulization, unitary diagonalization. Spectral theorem for normal matrices.

Jordan decomposition and singular value decomposition of matrices (only methods and not proofs). Generalized inverse: Definition and its computation. Perron’s and Frobenius Theorems (only statement) and their applications.

Quadratic Forms: Definite and semi definite quadratic forms, index and signatures, simultaneous diagonalization of symmetric matrices (equivalent quadratic forms), extrema of quadratic forms.

Books :


Note: The contents of this course are as per the scope of C. R. Rao Book.
Stat-102 : DISTRIBUTION THEORY

Objective: This course will lay the foundation to probability theory and Statistical modeling of outcomes of real life random experiments through various Statistical distributions.

Note:-
(i) The question paper will consist of eight questions carrying equal marks. A candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

(ii) Additional two hours workload per week will be allocated to this course in the afternoon for problem solving.


REFERENCES:

ADDITIONAL REFERENCES:
Stat-103 : STATISTICAL METHODS WITH PACKAGES (4 Credits)
(Theory 3/4, Practical 1/4)

Theory Final Examination : 60 Marks
Theory Internal Assessment : 15 Marks
Practical : 25 Marks

Objective : The objective of the course is to make the students conversant with various
techniques used in summarization and analysis of data. The focus will be both on theoretical as
well as practical approach using commonly used Statistical Software.

Note :- (i) The question paper will consist of eight questions carrying equal marks. The
candidate will be required to attempt five questions including the first
compulsory question in three hours duration. The compulsory question shall
contain short answer type questions covering the whole syllabus with no internal
choice.

(ii) The Practical question paper shall consist of five questions and a candidate will
be required to attempt any three questions in four hours duration.

Descriptive Statistics : Meaning, need and importance of statistics. Attributes and variables.
Measurement and measurement scales. Collection and tabulation of data. Diagrammatic
representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives,
stem and leaf plot, pie chart. Measures of central tendency, dispersion (including box and
whisker plot), skewness and kurtosis. Data on two attributes, independence and association of
attributes in 2x2 tables. Linear regression and correlation (Karl Pearson’s and Spearman’s) and
residual plots.

Vital Statistics (basics of demography) : Rates of vital events, measurements of mortality,
crude death rate, specific and standardized death rates. Life tables (description and construction).
Abridged life tables. Measurement of fertility, crude birth rate, general fertility rate, age-
specific and total fertility rates. Measurement of population growth, crude rate of natural
increase and vital index, gross and net reproduction rates.

Index Numbers : Meaning of index number. Problems in construction of index numbers:
purpose of the index, choice of base period, choice of commodities, choice of weights,
interpretation of the index. Laspeyser’s, Paasche’s and Fisher’s index numbers. Errors in index
numbers, tests for index numbers, cost of living index numbers. Uses of index numbers (real
wages, splicing and deflating).

Time Series : The four components of an economic time series. Trend determination: by
mathematical curve fitting and by moving average methods. Measurement of seasonal variations:
ratio to moving average method, ratio to trend method.

Sampling Distributions : Normal, Chi-square, t, and F distributions and their relations.
Population, random sample, parameter, statistic and sampling distribution. Sample mean
and sample variance associated with a random sample from a normal distribution: their
independence, sampling distributions, expectations and standard errors.

Tests of Significance : Statistical hypotheses, type I and II errors, level of significance, test of
significance, concept of p-value. Tests of significance for the parameters of normal distribution
(one sample and two sample problems) and the relevant confidence intervals. Chi-square
test of goodness of fit and independence of attributes. Test of significance for correlation
coefficient. ($\rho = 0, \rho = \rho_0$).

Use of Statistical packages : Topics should include graphic representation of data, descriptive
statistics, simple hypothesis tests, correlation and linear regression.
REFERENCES:

ADDITIONAL REFERENCES:
SEMESTER-II

Stat-201: STATISTICAL COMPUTING USING FORTRAN  (4 credits)
(Theory ½, Practical ½)

Objective: This course is divided into two parts i.e. Numerical Analysis and FORTRAN. First part of the course is about the study of numerical algorithms for mathematical calculations using computers. It contains algorithms for solving transcendental and polynomial equations, system of linear Algebraic equations, interpolation, extrapolation, numerical differentiation and integration. Second part introduces programming language -FORTRAN 77. Students learn to implement numerical methods being studied in theory using FORTRAN 77 on computers.

Note: - (i) Theory question paper of the final examination will consist of eight questions from numerical analysis only. Various questions will carry equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus of numerical analysis only with no internal choice.

(ii) The practical marks will be based entirely on internal assessment.

Computer System Concepts: Computer system components and functions. The central processing unit, Main memory, Bit, Byte, Input/Output Devices, Speeds and memory capacities in computer systems.

Software Concepts: Overview of operating systems, types and functions of operating system, application software, overview of existing software packages on Word Processing and Spreadsheets.

FORTRAN-77: Data types and constants, variable names, arithmetic and logical statements, control statements, logical IF, arithmetic IF, block IF, Do loops, unconditional GOTO, Computed GOTO statements. Arrays, character handling, intrinsic functions, statement functions and subroutines. File handling, equivalence, COMMON and DATA statements.

The purpose of this language is to write the program for solving various numerical problems in this course.

NUMERICAL ANALYSIS


Interpolation and Approximation: Lagrange & Newton interpolations, finite difference operators, interpolating polynomial using finite differences (Gregory Newton Forward and Backward difference interpolation, Stirling and Bessel interpolations, Hermite interpolation), bivariate interpolation (Lagrange bivariate interpolation, Newton's bivariate interpolation for equispaced points). Approximation (Weierstrass approximation). First order difference equations, linear difference equations with constant coefficients.


ADDITIONAL REFERENCES:

Stat-202 : ESTIMATION AND TESTING OF HYPOTHESES
(Theory 3/4, Practical 1/4)

Theory Final Examination : 60 Marks
Theory Internal Assessment : 15 Marks
Practical : 25 Marks

Objective: The objective of the course is to provide a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications.

Note: (i) The question paper will consist of eight questions carrying equal marks. The first question will be compulsory and it will contain short answer type questions covering the whole syllabus with no internal choice. A candidate will be required to attempt five questions, including the first compulsory question, in three hours duration.

(ii) The Practical question paper will consist of five questions. A candidate will be required to attempt any three questions in four hours duration.


Tests of Hypotheses: Concepts of critical regions, test functions, two kinds of errors, size function, power function, level of significance. MP and UMP tests in a class of size \(\alpha\) tests. Neyman - Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against one-sided alternatives and for one-sided null against one-sided alternatives in one parameter exponential family. Extension of these results to Pitman family when only upper or lower end depends on the parameter and to distributions with MLR property. Non-existence of UMP test for simple null against two-sided alternatives in one parameter exponential family. Likelihood Ratio Tests. Wald’s SPRT with prescribed errors of two types.

Interval Estimation: Confidence interval, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses. Tests of hypotheses and interval estimation viewed as decision problems with given loss functions.

REFERENCES:


ADDITIONAL REFERENCES:

Stat-203: SAMPLING THEORY AND OFFICIAL STATISTICS  (4 Credits)
(Theory ¾, Practical ¼)

Theory Final Examination : 60 Marks
Theory Internal Assessment : 15 Marks
Practical : 25 Marks

Objective: The objective of this course is to acquaint the students about: (i) the need & merits of
sampling over census and (ii) the implementation of various sampling schemes along with their merits,
demerits and comparisons in appropriate practical situations, (iii) role of various statistical organizations
in national development.

Note: (i) The question paper will consist of eight questions with the following division:
   (a) First question will be compulsory covering the entire syllabus.
   (b) Section-I: This section will have five questions from UNIT-I of the syllabus.
   (c) Section-II: This section will have two questions from UNIT-II of the syllabus.

   The compulsory question shall contain short answer type questions covering the whole syllabus
   with no internal choice.

   A candidate is required to attempt five questions in all, in three hours duration, including first
   compulsory question, selecting three questions from Section-I and one question from Section-II.

   (ii) The Practical question paper shall consist of five questions and a candidate will be required to
   attempt any three questions in four hours duration.

UNIT-I

Sample Surveys: Introduction to usual notations used in sampling. Basic finite population sampling
 techniques: SRSWOR, SRSWR, stratified, systematic and related results on estimation of population
 mean/ total. Relative precision of different sampling techniques. Allocation problem in stratified
 sampling.

Ratio and regression estimators based on SRSWOR method of sampling. Two-stage sampling with equal
 size of first stage units. Double sampling for ratio and regression methods of estimation. Cluster sampling-
 equal clusters.

Unequal Probability Sampling: PPS WR/WOR methods [cumulative total, Lahiri’s schemes] and
 related estimators of a finite population mean [Thompson-Horwitz, Yates and Grundy estimator, Desraj
 estimators for a general sample size and Murthy’s estimator for a sample of size 2].

UNIT-II

National sample surveys organization (NSSO) and role of various statistical organizations in national
development. Scope and contents of population census in India. Review of national income and their
estimates.
REFERENCES:


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SEMESTER III

Stat-301: NONPARAMETRIC INFERENCE (4 Credits)
(Theory ¾, Practical ¼)

Objective:
The objective of this course is to apprise the students about various techniques of hypothesis testing when
the assumptions of parametric set up are not fulfilled. Thrust will be to study various non-parametric
analogues to one, two and c-sample location problems as well as two sample scale problem.

Note:  
(i) The question paper will consist of eight questions carrying equal marks. The candidate will be
required to attempt five questions including the first compulsory question in three hours
duration. The compulsory question shall contain short answer type questions covering the
whole syllabus with no internal choice.

(ii) The practical question paper shall consist of five questions and a candidate will be required to
attempt any three questions in four hours duration.

Estimable parametric functions, kernel and Symmetric Kernel. One sample U-Statistic, Two sample
Empirical distribution function, confidence intervals based on order statistics for quantiles, tolerance
regions.

Tests for Randomness: Tests based on the total number of runs and runs up and down. Rank-order
statistics. One sample and paired-sample techniques: sign test and signed-rank test. Goodness of fit
problem: Chi-square and Kolmogorov-Smirnov tests. Independence in bivariate sample: Kendall’s and
Spearman’s rank correlation.

The General Two Sample Problem: Wald Wolfwilz run test and Kolmogorov-Smirnov two sample
test.

Linear Rank Statistics: Linear Rank Statistics and its limiting distribution, Rank test, MP and LMP rank
tests. Tests for two-sample location problem: Wilcoxon-Mann-Whitney, Terry-Hoeffding, Van der
Waerden, Median tests. Tests for two sample scale problem: Mood, Klotz, Capon, Ansari-Bradley,
Siegel-Tukey, and Sukhatme tests. Pitman asymptotic relative efficiency.

Tests for the C-sample Problem: Kruskal-Wallis, Jonckheere-Terpstra tests.

Concepts of Jackknifing method of Quenouille for reducing bias, Bootstrap methods.

REFERENCES:

   Statistics, John Wiley and Sons, Inc.
3. Davison, A.C. and Hinkley, D.V. (1997) : Bootstrap Methods and Their Application,
   Cambridge University Press.
   Wiley & Sons, Inc.
Stat-302 : STATISTICAL PROCESS AND QUALITY CONTROL (4 Credits)
(Theory 3/4, Practical 1/4)

Objective:
The paper shows the applications of Statistics to maintain quality in Engineering or industrial set up. The theory of control charts, sampling plans and process capability indices is the basis for judging whether the process is in statistical control or not. The topics are quite helpful during industrial training/placements of M.Sc. Students.

Note: (i) The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

(ii) The practical question paper shall consist of five questions and a candidate will be required to attempt any three questions in four hours duration.

The meaning of quality, quality assurance, technology and productivity. Statistical methods for quality control and improvement.

Chance and assignable causes of Quality Variation, General Theory of Control Charts, Control charts for variables : $\bar{X}$ and R chart; Analysis of pattern on Control Charts; Control Chart for attributes- np, p, c and u charts. Multiple Stream Processes: Group control charts. Specification limits and tolerance limits.

Process capability analysis, Introduction, Capability Indices – $C_p$, $C_{pk}$ and $C_{pm}$. Estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.


Acceptance Sampling Plans for Attribute Inspection : Single, double and sequential sampling plans and their properties, including OC, AOQL and ASN curves. Plans for inspection by variables for one-sided and two-sided specifications. Specification of Sampling plan by LTPD and AOQL. Mill Std plans; Dodge and Roming tables.

REFERENCES:


ADDITIONAL REFERENCES:

Stat 303: LINEAR INFEERENCE  
(Theory ¾, Practical ¼)  

(4 Credits)  

Theory Final Examination  : 60 Marks  
Theory Internal Assessment : 15 Marks  
Practical  : 25 Marks  

Objective: The students will get familiar with the need of modeling random responses using independent predictors through linear and logistic (for binary responses) models in real life situations. Least square estimation of parameters of these models will be discussed along with their statistical significance.

Note:-  
(i) The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

(ii) The Practical question paper shall consist of five questions and a candidate will be required to attempt any three questions in four hours duration.


Introduction to Estimation: Point and interval estimates, best linear unbiased estimates, construction of confidence intervals of the parameters of linear model.

Theory of Least Squares and Analysis of Variance: Gauss-Markoff set-up, normal equations, least squares estimates and their precision, use of g-inverse, statements and applications of fundamental theorems of least squares.

Introduction to fixed, mixed and random effect models. Tests of significance and interval estimates based on least squares theory in one-way and two-way classified data, a general model for two-way data, Bartlett test for testing of homogeneity of variances.


REFERENCES:

Chapters: 3b, 3c, 3d, 4a to 4e, 4f.1, 4g.1, 4g.3, 4g.4, 4h.
Chapters: 26, 32, 33, Springer–Verlag.
Objective: The course deals with the statistical estimation and testing problems when the underlying structure is not univariate but multivariate in nature. Various multivariate techniques (estimation and testing) required to handle two or more correlated response variables, will be discussed under multivariate normal setting. One sample, two sample and c-sample multivariate normal mean vector testing problems will be discussed.

Note: (i) The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

(ii) The practical question paper shall consist of five questions and a candidate will be required to attempt any three questions in four hours duration.


Null distribution of partial and multiple correlation coefficient. Application in testing and interval estimation.

Null distribution of Hotelling’s $T^2$ Statistic. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. Mahalanobis $D^2$ and its Sampling distribution.

Wishart distribution and its properties. Distribution of sample generalized variance. Classification and discriminant procedure for discriminating between two multivariate normal populations; sample discriminant function and tests associated with discriminant functions, probabilities of misclassification and their estimation.


Principle components, dimension reduction, Canonical variables and Canonical correlation: definition, use, estimation and computation.

REFERENCES:

Stat-402 : DESIGN & ANALYSIS OF EXPERIMENTS  
(Theory ¾, Practical ¼)  
(4 Credits)

Theory Final Examination : 60 Marks  
Theory Internal Assessment : 15 Marks  
Practical : 25 Marks

Objective:  To provide orientation of statistics while designing statistical experiments, particularly in agricultural set up and in pharmaceutical production processes. Exposure to various statistical designs leading to the analysis of variance, eliminating heterogeneity of the data, construction of designs will be provided.

Note:  
(i) The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

(ii) The practical question paper shall consist of five questions and a candidate will be required to attempt any three questions in four hours duration.

Three basic principles of design of experiments: randomisation, replication and local control. Design useful for one-way elimination of heterogeneity. Completely randomised, randomised complete block and balanced incomplete block designs. Concepts of balancing, orthogonality, connectedness and properties of C-matrix. General inter and intra block analysis of incomplete block designs. $2^2$, $2^3$, $3^2$ and $3^3$ factorial designs, fractional replication and split-plot designs. Design useful for two-way elimination of heterogeneity and their general method of analysis by using fixed effect model, Latin squares, Graeco Latin squares and Youden squares designs.

Missing plot techniques, illustrations of construction of s x s mutually orthogonal Latin squares and balanced incomplete block designs (by using finite geometries, symmetrically repeated differences and known B.I.B. designs).

REFERENCES :

MODULE

M 1: ACTUARIAL STATISTICS (4 Credits)

Final Examination : 80 Marks
Internal Assessment : 20 Marks

Note: The question paper will consist of eight questions carrying equal marks. The first question will be compulsory containing short answer type questions covering the entire syllabus and with no internal choice. Section-I will have four questions on Probability models and Life Tables and Section-II will have three questions on Insurance and Annuities. A candidate will be required to attempt five questions in three hours duration, including the first compulsory question and selecting at least two from Section-I and at least one from Section-II.

Section I-Probability Models and Life Tables:
Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtail future lifetime, force of mortality.
Life table and its relation with survival function, examples.
Multiple life functions, joint life and last survivor status.
Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement.
Distribution of aggregate claims, compound Poisson distribution and its applications. Claim amount distributions, approximating the individual model, Stop-loss insurance.

Section II – Insurance and Annuities:
Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor.
Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance.
Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, varying annuities.
Net premiums: Continuous and discrete premiums, true monthly payment premiums.
Net premium reserves: Continuous and discrete net premium reserves, reserves on a semicontinuous basis, reserves based on true monthly premiums.

REFERENCES:
   Section I – Chapters: 1, 2, 3, 8, 9, 11, 13.
   Section II – Chapters: 4, 5, 6, 7.

ADDITIONAL REFERENCES:
M 2: CATEGORICAL DATA ANALYSIS (4 Credits)

Final Examination: 80 Marks
Internal Assessment: 20 Marks

Note: The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

Categorical response variables: Nominal, ordinal, interval Categorical data describing two-way contingency tables, measures of nominal and ordinal association, inference for two-way contingency tables, likelihood functions and maximum likelihood estimates, testing goodness of fit and testing independence. Screening tests, sensitivity, specificity, and predictive value positive and negative, partitioning chi-squared, large sample confidence intervals, delta method to estimate standard error, exact tests for small samples.

Models for binary response variables: Generalized linear models, logit, log linear, linear probability and logistic regression models. Logit models for categorical data, probit and extreme value models, models with log-log link, model diagnostics.


REFERENCES:

1. Agresti, Alan : Categorical Data Analysis.
M 3 : ECONOMETRICS

(4 Credits)

Final Examination : 80 Marks
Internal Assessment : 20 Marks

Note :- The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

Nature of econometrics. The general linear model (GLM) and its assumptions. Ordinary least squares (OLS) estimation and prediction. Significance tests and confidence intervals, linear restrictions. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation and prediction. Heteroscedastic disturbances.


Estimation in simultaneous equations model. Recursive systems. 2 SLS estimators, k-class estimators. 3SLS estimation. Full information maximum likelihood method. Prediction and simultaneous confidence intervals. Monte Carlo studies and simulation.

REFERENCES :

M 4: ECONOMIC STATISTICS

(4 Credits)

Final Examination : 80 Marks
Internal Assessment : 20 Marks

Note :- The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

Introduction to Economic Science.

1. The Theory of Consumer Behaviour : Utility function, indifference curves and their properties, price and income elasticities, substitution and income effects.


5. Inequality of income, Gini coefficient, Lorenz curve mathematically & its deviation for some well-known income distribution function.

REFERENCES :

M 5: ADVANCED INERENCE
(Theory ¾, Practical ¼)

(6 Credits)

Theory Final Examination : 80 Marks
Theory Internal Assessment : 20 Marks
Practical : 50 Marks

Note :- (i) The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

(ii) The Practical question paper shall consist of five questions and a candidate will be required to attempt any three questions in four hours duration.

Review of convergence in probability and convergence in distribution, Cramer and Slutsky’s Theorems.

Consistent Estimation of real and vector valued parameters. Invariance of Consistent estimator under continuous transformation, consistency of estimators by method of moments, and method of percentiles, mean squared error criterion, asymptotic relative efficiency, error probabilities and their rates of convergence. Minimum sample size required to attain given level of accuracy.

Consistent Asymptotic Normal (CAN) estimator, invariance of CAN estimator under differentiable transformation, CAN property of estimators obtained by moments and percentiles, CAN estimators obtained by moment and MLE method in one parameter exponential family, extension to multi-parameter exponential family, examples of consistent but not asymptotically normal estimators from Pitman family. Method of maximum likelihood, CAN estimators for one-parameter Cramer family, Cramer – Huzurbazar theorem. Solution of likelihood equations, method of scoring, Newton–Raphson and other iterative procedures, Fisher Lower bound to asymptotic variance, extension to multi-parameter case (without proof). Multinomial distribution with cell probabilities depending on a parameter.

MLE in Pitman family and double exponential distribution, MLE in censored and truncated distributions.

Likelihood Ratio Test (LRT), asymptotic distribution of LRT statistic, Wald test, Rao’s score test, Pearson’s chi-square test for goodness of fit, Bartlett’s test for homogeneity of variances. Large sample tests and confidence intervals based on CAN estimators, variance stabilizing transformation and large sample tests. Consistency of large sample tests, asymptotic power of large sample tests.

REFERENCES:


ADDITIONAL REFERENCES:

M 6 : MEASURE & PROBABILITY THEORY (4 Credits)

Final Examination : 80 Marks
Internal Assessment : 20 Marks

Note :- The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

Measure Theory : Classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma-field in $\mathbb{R}^k$. Measure, probability measure, properties of a measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue-Stieljes measures on $\mathbb{R}^k$.


Convergence in distribution, characteristic function, uniqueness theorem, inversion theorem (statement and applications only), Levy’s continuity theorem (statement only), CLT for a sequence of independent random variables under Lindeberg’s condition, CLT for iid random variables.

REFERENCES :


ADDITIONAL REFERENCES :

**M 7: OPERATIONS RESEARCH**

(4 Credits)

<table>
<thead>
<tr>
<th>Theory Final Examination</th>
<th>60 Marks</th>
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<tbody>
<tr>
<td>Theory Internal Assessment</td>
<td>15 Marks</td>
</tr>
<tr>
<td>Practical</td>
<td>25 Marks</td>
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</tbody>
</table>

**Note:**

(i) The question paper will consist of eight questions carrying equal marks. The first question will be compulsory containing short answer type questions covering the entire syllabus and with no internal choice. The candidate will be required to attempt five questions including the first compulsory question in **three hours duration**.

(ii) The Practical question paper shall consist of five questions and a candidate will be required to attempt any three questions in **four hours duration**.

Origin and development of operations research (O.R.), modelling in O.R., applications of O.R., opportunities and shortcomings of O.R.

Formulation of linear programming problem (LPP), graphical solution to LPP, properties of a solution to the (LPP), generating extreme point solutions. The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, the artificial basis technique. Two phase method and Charnes M-method with artificial variables. The duality problem of linear programming and its economic interpretation, transportation and assignment problems. Sensitivity analysis, network flow problem. Game theory problem as a linear programming problem, integer programming.

Replacement models & sequencing theory, inventory models with single and multiple periods, ABC analysis, general simulation problems.

**REFERENCES :**


**ADDITIONAL REFERENCES :**

M 8: REAL & COMPLEX ANALYSIS  

(4 Credits)

**Final Examination**  : 80 Marks  
**Internal Assessment**  : 20 Marks

**Note**: The question paper will consist of nine questions carrying equal marks. The first question will be compulsory containing short answer type questions covering the entire syllabus and with no internal choice. Section-I will have five questions on Real Analysis and Section-II will have three questions on Complex Analysis. A candidate will be required to attempt five questions in *three hours duration*, including the first compulsory question and selecting at least two questions from Section-I and at least one question from Section – II.

**SECTION-I**

Sequence of sets, limit sup and limit inf of a sequence of sets. Countable and uncountable sets, open and closed intervals (rectangles), compact sets, Bolzano-Weirestrass theorem (statement only). Heine – Borel theorem (statement only). Properties of continuous functions on compact sets.


Fourier series of a function relative to an orthogonal system of functions, convergence of Fourier series to its defining functions.

**SECTION-II**

Complex Numbers, geometrical representation of complex numbers, functions of a complex variable, differentiability and analyticity, Cauchy-Riemann conditions.

Elementary, exponential and logarithmic functions.

Power series, radius of convergence, differentiation of a power series, Taylor’s and Laurent’s series, Residues. Integration of a function of a complex variable, Cauchy’s theorem and Cauchy’s Integral theorem (Statement and applications only).

Applications of Residues: Evaluation of definite and improper integrals.

**REFERENCES**

ADDITIONAL REFERENCES:

M 9: RELIABILITY

(4 Credits)

Final Examination: 80 Marks

Internal Assessment: 20 Marks

Note: The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

Reliability concepts and measures: components and systems, coherent systems, reliability of coherent systems, cuts and paths, modular decomposition, bounds on system reliability, structural and reliability importance of components.

Life distributions and associated survival, conditional survival and hazard rate functions. Exponential, Weibull, gamma life distributions and estimation of their parameters.

Notions of ageing. IFR IFRA, NBU, DMRL, NBUE, and HNBUE classes; their duals and relationships between them. Closures of these classes under formation of coherent systems, convolutions and mixtures.

Partial orderings: Convex, star, stochastic, failure rate and mean-residual life orderings. Univariate shock models and life distributions arising out of them. Maintenance and replacement policies, availability of repairable systems. Introduction to accelerated life testing.

REFERENCES:

M 10: SIMULTANEOUS INference  

(4 Credits)  

Final Examination : 80 Marks  
Internal Assessment : 20 Marks  

Note :- The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice. 

Introduction to simultaneous inference, error rates, Bonferroni inequality, p-mean significance levels, basic techniques of multiple comparisons and their geometrical interpretation for the case of two means. 

Studentized range, Scheffe’s F-projections, Bonferroni t-statistics, studentized maximum modulus, many-one t-statistics, Duncan’s multiple range test, Newman-Keuls test, Fisher’s LSD test, Tukey’s gap-straggler-variance test, two-sample confidence intervals of predetermined length, and improved Bonferroni inequality. 

Many-one sign statistics, k-sample sign statistics, many-one rank statistics, k-sample rank statistics, signed-rank statistics, Kruskal-Wallis rank statistics, Friedman rank statistics, and permutation test. 

Multivariate techniques: Single population with covariance scalar unknown, single population with covariance matrix unknown. 

REFERENCES: 

1. R.G. Miller (Jr.) : Simultaneous Statistical Inference, Springer-Verlag, Chapters 1, 2, 4, 5 (Sections 5.1 and 5.2).  
M 11 : STATISTICAL SIMULATION AND COMPUTATION
(Theory 1/2, Practical 1/2) (4 Credits)

Theory Final Examination : 40 Marks
Theory Internal Assessment : 10 Marks
Practical : 50 Marks

Note:- (i) The Theory question paper of the final examination will consist of eight questions from Simulation only. Various questions will carry equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

(ii) The practical marks will be based entirely on internal assessment.

Introduction Function to C : Data types, operator and expressions, Input/Output statement, control statement functions, Arrays, Structures.


Random Number Generation: Congruential generators, statistical tests for pseudo random numbers.


Monte Carlo integration and variance reduction techniques : Hit or miss Monte Carlo method, sample mean Monte Carlo method, importance sampling, correlated sampling control variates, stratified sampling, antithetic variates, partition of region.

Introduction to Pattern Recognition: Pattern classification by likelihood functions.

REFERENCES:

M 12: STOCHASTIC PROCESSES (4 Credits)

Final Examination : 80 Marks
Internal Assessment : 20 Marks

Objective: The main objective of this course is to apprise the students about the existence of several stochastic processes in real life situations and to equip them with the techniques to study their statistical behavior as a sequence of dependent random variables.

Note: The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.


Discrete state space continuous time Markov Processes; Wiener process, Kolmogorov-Feller differential equations, Poisson process, birth and death process.

Renewal theory: Renewal process, elementary renewal theorem and applications. Statement and uses of key renewal theorem, study of residual lifetime processes.

Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size.

REFERENCES:

M 13 : SURVIVAL ANALYSIS

(4 Credits)

Final Examination : 80 Marks
Internal Assessment : 20 Marks

Note :- The question paper will consist of eight questions carrying equal marks. The candidate will be required to attempt five questions including the first compulsory question in three hours duration. The compulsory question shall contain short answer type questions covering the whole syllabus with no internal choice.

Concepts of Type-I (time), Type-II (order) and random censoring likelihood in these cases. Life distributions, exponential, gamma, Weibull, lognormal, Pareto, linear failure rate. Inference for exponential, gamma, Weibull distributions under censoring.

Failure rate, mean residual life and their elementary properties. Ageing classes and their properties, bathtub failure rate.

Estimation of survival function – Actuarial estimator, Kaplan –Meier estimator, Tests of exponentiality against non-parametric classes: Total time on Test, Deshpande Test.

Two sample problem : Gehan test, Log rank test. Mantel-Haenszel test, Cox’s proportional hazards model, competing risks model.

REFERENCES :


Published by : Professor A.K. Bhandari, Registrar, Panjab University, Chandigarh.