DEPARTMENT OF STATISTICS

The following courses were approved by the respective Committee of courses on 09.01.23. Draft syllabi are enclosed for further suggestions. All suggestions are welcome by 11.01.23, Wednesday before 11.59 pm for consideration of the related Committee of Courses to be held on Thursday, 12.01.23.

B. Sc. (H) Statistics

Category-I

DISCIPLINE SPECIFIC CORE COURSE-10: SAMPLING DISTRIBUTIONS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Theory of probability distributions	4	3	0	1	B.Sc.(H) Statistics, Semester III	DSC-1,2,4 and 8

Learning Objectives

The learning objectives of this course are as follows:

- To learn about modes of convergence and their relation to limit laws, with focus on the central limit theorem.
- To understand the concept of sampling distributions and their applications in statistical inference.
- To understand the statistical ideas behind the procedure of hypothesis testing.
- To have a clear understanding of assumptions and conditions under which to apply different tests of hypothesis about population parameters and draw appropriate conclusions from the analysis.

Learning Outcomes

The learning outcomes of this course are as follows:

- Students will have knowledge of the basics of convergence theory and their importance in limit laws.

- Students will have a clear understanding of the concept of central limit theorem, and relevance of the theorem in inferential statistics.
- Students will be able to analyze data by using suitable hypothesis testing procedures in real life applications related to large and small samples.
- They will have knowledge and understanding of the idea of sampling distributions and their importance in the field of statistics.
- This course will enable students to apply knowledge of various sampling distributions like chi square, t and F distributions in hypothesis testing problems.

SYLLABUS OF DSC-10

Theory – 45 Hours

UNIT I **(04 Weeks)**

Modes of Convergence: Convergence in probability, convergence with probability one, convergence in mean square, convergence in distribution – definitions and relations between the various modes.

Chebyshev's inequality, Weak Law of .Large Numbers (WLLN), Strong Law of Large Numbers (SLLN) along with examples and applications.

Central Limit Theorem (C.L.T.): Basic idea and relevance, De-Moivre Laplace theorem, Lindeberg Levy theorem, Liapunov Theorem (only statement) and applications of C.L.T.

Order Statistics: Basic concept and discussion on area of applications, probability distribution and cumulative distribution function of a single order statistic, joint probability distribution of two and the general case of all order statistics, distribution of range and distribution of sample median.

UNIT II **(04 Weeks)**

Sampling Distributions: Concepts of parameter, statistic, sampling distribution of a statistic, standard error. Sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion.

Testing of Hypothesis: Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region, determination of sample size, confidence intervals, p value.

Large Sample Tests (by classical and p-value approaches): Tests of significance and confidence intervals for - single proportion, difference of two proportions, single mean, difference of two means and difference of two standard deviations.

UNIT III **(03 Weeks)**

Exact Sampling Distributions Chi Square distribution: Definition and derivation of probability distribution of chi square distribution with n degrees of freedom, nature of the curve for different degrees of freedom, mean, mode, variance, moment generating function, cumulant generating function additive property and limiting form of the chi square distribution. Applications of Chi Square distribution.

UNIT IV **(04**

Weeks)

Exact Sampling Distributions (continued): Student's t statistic and Fishers t-statistic: definition and derivation of their sampling distributions, nature and characteristics of graph of t distribution, moments, limiting form and applications of t distribution.

F-statistic: Definition and derivation of sampling distribution, graph of F distribution, moments and applications of F distribution. Relationship between t, F and chi square distributions.

PRACTICAL – 30 Hours

List of Practicals:

1. Practical based on test of significance for single proportion for large samples.
2. Practical based on test of significance for difference of proportions for large samples.
3. Practical based on test of significance for single mean for large samples.
4. Practical based on test of significance for difference of two means for large samples.
5. Practical based on test of significance for difference of two standard deviations for large samples.
6. Practical based on chi square test for population variance.
7. Practical based on chi square test for goodness of fit.
8. Practical based on chi square test for independence of attributes.
9. Practical based on application of Yate's correction.
10. Practical based on t test of significance for single mean for small samples.
11. Practical based on t test of significance for difference of two means for independent samples.
12. Practical based on paired t test of significance for difference of two means.
13. Practical based on test of significance of observed sample correlation coefficient.
14. Practical based on F test for equality of variances.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

ESSENTIAL READINGS

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2016). *An Outline of Statistical Theory*, Volume I, The World Press, Kolkata.
- Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, Twelfth Edition, S. Chand and Sons. Delhi.
- Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). *Probability and Statistical Inference*, Seventh Edition, Pearson Education, New Delhi.
- Johnson, R.A. and Bhattacharya, G.K. (2001). Statistics-Principles and Methods, Fourth Edition, John Wiley and Sons.
- Miller, I. and Miller, M. (2006). *John E. Freund's Mathematical Statistics with Applications*, Eight Edition, Pearson Education, Asia.

- Mukhopadhyay, P. (2016). *Mathematical Statistics*, Books and Allied, India.

SUGGESTED READINGS

- Mood, A.M. Graybill, F.A. and Boes, D.C. (2007). *Introduction to the Theory of Statistics*, Third Edition, (Reprint), Tata McGraw-Hill Pub. Co.Ltd.
- Rohatgi, V. K and Saleh M. E. (2015). *An Introduction to Probability and Statistics*, Third Edition, John Wiley and Sons, Inc., New Jersey.
- Bhat, B.R. (2016). *Modern Probability Theory- An Introductory Textbook*, Fourth Edition, New Age International Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

STAT-DSC-11: Total Quality Management

DISCIPLINE SPECIFIC CORE COURSE 12: TOTAL QUALITY MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Total Quality Management	**4**	**3**	**0**	**1**	**Basic Knowledge of Statistics**	

Learning Objectives:

The learning objectives include:

- This course will help students to learn statistical and management techniques and approach of Quality control being used in industry to manufacture goods and services of high quality at low cost.
- This course will also give exposure to Six-sigma, TQM which is high on demand in market both in manufacturing as well as service sector

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Quality, Historical background, ISO standards.
- Statistical process control tools- Control charts for variables, attributes
- Statistical product control tools- Sampling inspection plans, Dodge and Romig plans
- Overview of Six sigma- Lean manufacturing, TQM
- Six sigma training plans, VOC, CTQ
- Application of DMAIC

Contents:

UNIT I **(9 hours)**

Basics of Quality Management

Quality: Definition, dimensions of quality, its concept, application and importance. Brief historical perspective of quality control and improvements, Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration. Introduction to Process and Product Control, Statistical Process Control - Seven tools of SPC, Chance and Assignable causes of quality variation.

UNIT II **(12 hours)**

Statistical Control Charts

Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts,. Control charts for variables: X-bar & R-chart, X-bar & s-chart. Rational Sub-grouping, Revised and Modified Control Limits. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.

UNIT III **(12 hours)**

Sampling PLans

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

UNIT IV **(12 hours)**

Six-Sigma

Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans-Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ), Introduction to DMAIC.

PRACTICAL/LAB. WORK:

List of Practical

1. Construction and interpretation of statistical control charts X-bar & R-chart for known parameters.
2. Construction and interpretation of statistical control charts X-bar & R-chart with revised control limits for unknown parameters.
3. Construction and interpretation of statistical control charts X-bar & s-chart with revised control limits
4. Construction and interpretation of statistical control charts np-chart
5. Construction and interpretation of statistical control charts p-chart with fixed sample size.
6. Construction and interpretation of statistical control charts p-chart with variable sample size.
7. Construction and interpretation of statistical control charts c-chart
8. Construction and interpretation of statistical control charts u-chart
9. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
10. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves for varying acceptance number.
11. Calculation of process capability and comparison of 3-sigma control limits with specification limits.

Plan a single sampling plan using Dodge and Romig sampling inspection tables.

Suggested reading:

- Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
- Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
- Gupta S.C., Kapoor V.K.(2007): Fundamentals of Applied Statistics. 4th Edition, Sultan Chand and Sons., New Delhi.
- Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.
- Hoyle, David (1995): *ISO Quality Systems Handbook*, 2nd Edition, Butterworth Heinemann Publication.

Discipline Specific Core Course-12: Time Series Analysis

Credit – 4

Course Objectives:
The Learning Objectives of this course are as follows:

1. To introduce basic time series analysis, trend, and seasonality,
2. To understand spectral analysis,
3. To familiarise students with stationary processes,
4. To understand various time series models,
5. To use nonstationary and seasonal time series models,
6. To introduce forecasting techniques and forecasting methods.

Course Learning Outcomes:
After completing this course:

1. Students will learn about important time series models and their applications in various fields.
2. Students will be able to formulate real-life problems using time series models.
3. Students will be able to use statistical software to estimate the models from real data, and draw conclusions and develop solutions from the estimated models.
4. Students will learn to use visual and numerical diagnostics to assess the soundness of their models.
5. Students will learn to communicate the statistical analyses of substantial data sets through explanatory text, tables, and graphs.
6. Students will learn to combine and adapt different statistical models to analyze larger and more complex data.
7. Students will possess skills to understand the components and forecast values of a time series at future time points.

Contents:

UNIT I: Time Series Data and its components (2 weeks)
Introduction to times series data and its applications; Components of a time series and its decomposition; Estimation of trend and the seasonal component.

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UNIT II: Spectral Analysis and Stationarity (3 weeks)
Simple sinusoidal model; Periodogram, and Harmonic Analysis; Variate-difference method; Time series, and Stochastic process; Stationarity; Autocorrelation; meaning, definition, causes, the consequence, and test for autocorrelation.

UNIT III: Time Series Models (5 weeks)
Stochastic Models: White noise Process, Random walk, MA, AR, ARMA, and their properties using correlogram, ACF, and PACF, Yule walker equations; Fitting of AR(1), AR(2), MA(1), MA(2), and ARMA(1,1) process. Non-Stationary models: ARIMA and SARIMA models; Dicky

Fuller test, Augmented Dickey-Fuller test. Wold's Decomposition Theorem; Non-linear time series models: ARCH and GARCH Process.

UNIT IV: Univariate Forecasting Procedures (4 weeks)

Principles of Forecasting; Performance Evaluation; Extrapolation of Trend Curves; Exponential smoothing; Holt-Winter's; Box- Jenkins' Methodology.

PRACTICAL / LAB WORK

List of Practicals:

1. Fitting and plotting of modified exponential curves by different methods.
2. Fitting and plotting of Gompertz curve by different methods.
3. Fitting and plotting of logistic curves by different methods.
4. Fitting of the trend by the Moving Average Method for a given extent and for an estimated extent.
5. Measurement of Seasonal indices: a) Fixed and b) Changing Patterns
6. Construction of Periodogram and Harmonic Analysis
7. Estimation of variance of the random component
8. Construction of Correlogram for given AR(1), AR(2), MA(1), MA(2), and ARMA(1,1) processes.
9. Fitting of AR(1), AR(2), MA(1), MA(2), and ARMA(1,1) processes for given datasets.
10. Forecasting by various exponential smoothing procedures.
11. Forecasting by Box-Jenkins methodology.

(May be done using EXCEL/SPSS/R)

ESSENTIAL READINGS:

1. Chatfield, C. (1996): The Analysis of Time Series, 5th Edition, Chapman and Hall, New York.
2. Shumway and Stoffer (2011): Time Series Analysis and its applications, with examples in R, 3rd Edition, Springer.
3. James D. Hamilton (2012): Time Series Analysis, 1st Indian Edition, Princeton University Press, Levant Books Kolkata.
4. Galit Shmueli and Kenneth C. Lichtendahl Jr (2016): Practical Time Series Forecasting with R: A Hands-On Guide, 2nd Edition, Axelrod Schnall Publishers
5. Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume II, 9th Edition and 4th reprint.

ADDITIONAL READINGS:

1. Montgomery D. C. and Johnson, L A. and (1967): Introduction To Time Series Analysis And Forecasting, 2nd ed. McGraw-Hill, New York.
2. Kendall M.G. (1976): Time Series, Charles Griffin.

3. Brockwell, Peter J., and Davis, Richard A. (2002). Introduction to Time Series and Forecasting, 2nd edition. Springer-Verlag, New York.

B.Sc. (P)/B.A(P) with Statistics as Major

Category II

Core 7: Statistical Inference

Course Objectives:

The learning objectives include:

- Concept of estimation theory and testing of hypothesis.
- Drawing inference about the unknown population parameters based on random samples.
- Validate the estimation/ inference about the population using hypothesis testing.

Course Learning Outcomes:

After completing this course, students will possess skills concerning:

- Understanding of estimation theory, Point and interval estimations.
- Characteristics of a good estimator and different methods of estimation.
- Demonstrate the use of these techniques in data analysis.
- Develop the best/most powerful statistical tests to test the hypotheses regarding unknown population parameters by using Neyman-Pearson theory.

Contents:

Unit I:

Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators, Factorization theorem, Fisher- Neyman Criterion: statement and applications, Cramer- Rao inequality: statement and application, MVB estimators and their applications, Statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem..

Unit II:

Methods of estimation: maximum likelihood, least squares and minimum variance, Properties of maximum likelihood estimators (illustration), Interval Estimation: confidence interval and confidence limits for the parameters of normal distribution, confidence intervals for large samples.

Unit III:

Principles of test of significance: Null and alternative hypotheses, simple and composite, Type-I and Type-II errors, critical region, level of significance, power of the test, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU), Neyman- Pearson Lemma: statement and its applications to construct most powerful test.

List of Practical / Lab Work:

1. Unbiased estimators and consistent estimators.
2. Efficient estimators and relative efficiency of estimators.
3. Sufficient estimators and factorization theorem.
4. Cramer- Rao inequality and MVB estimators.
5. Method of maximum likelihood estimation.
6. Method of least squares and minimum variance.
7. Confidence interval and confidence limits for the parameters of normal distribution.
8. Confidence intervals in case of large samples.
9. Type I and Type II errors, power of the test.
10. Most powerful critical region (NP Lemma).

Essential Readings:

- Miller, I. and Miller, M. (2013). *John E. Freund's Mathematical Statistics*, 8th Ed., Prentice Hall of India.
- S.C. Gupta and V.K. Kapoor (2020): *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.
- R.V. Hogg, A.T. Craig and J.W. Mckean (2005): *Introduction to Mathematical Statistics*, 6th Edition, Pearson Education.
- A.M. Goon, M.K. Gupta and B. Das Gupta (2003): *An Outline of Statistical Theory* (Vol. II), 4th Ed.,World Press, Kolkata.

Suggested Readings:

- G. Casella and R.L. Berger (2002): Statistical Inference, 2nd Edition, Thomson Duxbury.
- E.J. Dudewicz and S.N. Mishra (1988): Modern Mathematical Statistics, John Wiley and Sons.
- V.K. Rohtagi and A.K. Md. E. Saleh (2009): An Introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons.
- Mood A.M., Graybill F.A. and Boes D.C. (1974). Introduction to the Theory of Statistics, McGraw Hill.

DSC 8: Vital Statistics and Demography

Credits: 4

Course Objectives:

The learning objectives include:

- To collect valid Demographic data using different methods.
- To learn basic measures of Mortality, Fertility, and Population Growth.
- To construct life tables.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The distinction between Vital Statistics and Demography.
- Errors in Demographic data.
- Sources of data collection on Vital Statistics and errors therein.
- Measurement of Population.
- The distinction between Rate and Ratio.
- Basic measures of Mortality.
- Concepts of Stable and Stationary Populations.
- Concept of Life Tables, their construction, and uses.
- Basic measures of Fertility.
- Measures of Population Growth.

Contents:

UNIT I:

Introduction and sources of collecting data on vital statistics, errors in the census, and registration data. Measurement of population, rate, and the ratio of vital events.

UNIT II: Measurements of Mortality

Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR), and Standardized Death Rates. Stationary and Stable population, Central Mortality Rates, and Force of Mortality.

UNIT III: Life Tables

Life(Mortality) Tables: Assumption, description, construction of Life Tables, and Uses of Life Tables.

UNIT IV: Measurements of Fertility

Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR), and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR), and Net Reproduction Rate (NRR).

PRACTICAL/LAB WORK

List of Practical:

1. To calculate CDR and Age Specific death rate for a given set of data.
2. To find a standardized death rate by (i) Direct method and (ii) Indirect method.
3. To construct a complete life table.
4. To fill in the missing entries in a life table.
5. To calculate CBR, GFR, SFR, TFR for a given set of data.
6. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
7. Calculate GRR and NRR for a given set of data and compare them.

SUGGESTED READINGS:

1. Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
2. Croxton, Fredrick, E. Cowden, Dudley J. and Klein, S. (1973). Applied General Statistics, 3rd Ed., Prentice Hall of India Pvt. Ltd.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, 9thEd., World Press.
4. Keyfitz, N. and Beekman,J.A. (1985). Demography through Problems. S-Verlag, New York.
5. Mukhopadhyay, P. (1999). Applied Statistics, Books and Allied (P) Ltd.

B.Sc. (P)/B.A(P) with Statistics as Non- Major

Category III

Core 4: Statistical Inference

Course Objectives:

The learning objectives include:

- Concept of estimation theory and testing of hypothesis.
- Drawing inference about the unknown population parameters based on random samples.
- Validate the estimation/ inference about the population using hypothesis testing.

Course Learning Outcomes:

After completing this course, students will possess skills concerning:

- Understanding of estimation theory, Point and interval estimations.
- Characteristics of a good estimator and different methods of estimation.
- Demonstrate the use of these techniques in data analysis.
- Develop the best/most powerful statistical tests to test the hypotheses regarding

unknown population parameters by using Neyman-Pearson theory.

Contents:

Unit I:

Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators, Factorization theorem, Fisher- Neyman Criterion: statement and applications, Cramer- Rao inequality: statement and application, MVB estimators and their applications, Statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem..

Unit II:

Methods of estimation: maximum likelihood, least squares and minimum variance, Properties of maximum likelihood estimators (illustration), Interval Estimation: confidence interval and confidence limits for the parameters of normal distribution, confidence intervals for large samples.

Unit III:

Principles of test of significance: Null and alternative hypotheses, simple and composite, Type-I and Type-II errors, critical region, level of significance, power of the test, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU), Neyman- Pearson Lemma: statement and its applications to construct most powerful test.

List of Practical / Lab Work:

11. Unbiased estimators and consistent estimators.
12. Efficient estimators and relative efficiency of estimators.
13. Sufficient estimators and factorization theorem.
14. Cramer- Rao inequality and MVB estimators.
15. Method of maximum likelihood estimation.
16. Method of least squares and minimum variance.
17. Confidence interval and confidence limits for the parameters of normal distribution.
18. Confidence intervals in case of large samples.
19. Type I and Type II errors, power of the test.
20. Most powerful critical region (NP Lemma).

Essential Readings:

- Miller, I. and Miller, M. (2013). *John E. Freund's Mathematical Statistics*, 8th Ed., Prentice Hall of India.

- S.C. Gupta and V.K. Kapoor (2020): *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.
- R.V. Hogg, A.T. Craig and J.W. Mckean (2005): *Introduction to Mathematical Statistics*, 6th Edition, Pearson Education.
- A.M. Goon, M.K. Gupta and B. Das Gupta (2003): *An Outline of Statistical Theory* (Vol. II), 4th Ed.,World Press, Kolkata.

Suggested Readings:

- G. Casella and R.L. Berger (2002): Statistical Inference, 2nd Edition, Thomson Duxbury.
- E.J. Dudewicz and S.N. Mishra (1988): Modern Mathematical Statistics, John Wiley and Sons.
- V.K. Rohtagi and A.K. Md. E. Saleh (2009): An Introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons.
- Mood A.M., Graybill F.A. and Boes D.C. (1974). Introduction to the Theory of Statistics, McGraw Hill.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY DEPARTMENT OF STATISTICS
CATEGORY-IV

GE 4A: Statistical Inference

Course Objectives:

The learning objectives include:

- Concept of estimation theory and testing of hypothesis.
- Drawing inference about the unknown population parameters based on random samples.
- Validate the estimation/ inference about the population using hypothesis testing.

Course Learning Outcomes:

After completing this course, students will possess skills concerning:

- Understanding of estimation theory, Point and interval estimations.
- Characteristics of a good estimator and different methods of estimation.
- Demonstrate the use of these techniques in data analysis.
- Develop the best/most powerful statistical tests to test the hypotheses regarding unknown population parameters by using Neyman-Pearson theory.

Contents:

Unit I:

Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators, Factorization theorem, Fisher- Neyman Criterion: statement and applications, Cramer- Rao inequality: statement and application, MVB estimators and their applications, Statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem..

Unit II:

Methods of estimation: maximum likelihood, least squares and minimum variance, Properties of maximum likelihood estimators (illustration), Interval Estimation: confidence interval and confidence limits for the parameters of normal distribution, confidence intervals for large samples.

Unit III:

Principles of test of significance: Null and alternative hypotheses, simple and composite, Type-I and Type-II errors, critical region, level of significance, power of the test, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU), Neyman- Pearson Lemma: statement and its applications to construct most powerful test.

List of Practical / Lab Work:

21. Unbiased estimators and consistent estimators.
22. Efficient estimators and relative efficiency of estimators.
23. Sufficient estimators and factorization theorem.
24. Cramer- Rao inequality and MVB estimators.
25. Method of maximum likelihood estimation.
26. Method of least squares and minimum variance.
27. Confidence interval and confidence limits for the parameters of normal distribution.
28. Confidence intervals in case of large samples.
29. Type I and Type II errors, power of the test.
30. Most powerful critical region (NP Lemma).

Essential Readings:

- Miller, I. and Miller, M. (2013). *John E. Freund's Mathematical Statistics*, 8th Ed., Prentice Hall of India.
- S.C. Gupta and V.K. Kapoor (2020): *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.
- R.V. Hogg, A.T. Craig and J.W. Mckean (2005): *Introduction to Mathematical Statistics*, 6th Edition, Pearson Education.

- A.M. Goon, M.K. Gupta and B. Das Gupta (2003): *An Outline of Statistical Theory* (Vol. II), 4th Ed.,World Press, Kolkata.

Suggested Readings:

- G. Casella and R.L. Berger (2002): Statistical Inference, 2nd Edition, Thomson Duxbury.
- E.J. Dudewicz and S.N. Mishra (1988): Modern Mathematical Statistics, John Wiley and Sons.
- V.K. Rohtagi and A.K. Md. E. Saleh (2009): An Introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons.
- Mood A.M., Graybill F.A. and Boes D.C. (1974). Introduction to the Theory of Statistics, McGraw Hill.

GE 4 B: Vital Statistics and Demography

Credits: 4

Course Objectives:

The learning objectives include:

- To collect valid Demographic data using different methods.
- To learn basic measures of Mortality, Fertility, and Population Growth.
- To construct life tables.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The distinction between Vital Statistics and Demography.
- Errors in Demographic data.
- Sources of data collection on Vital Statistics and errors therein.
- Measurement of Population.
- The distinction between Rate and Ratio.
- Basic measures of Mortality.
- Concepts of Stable and Stationary Populations.
- Concept of Life Tables, their construction, and uses.
- Basic measures of Fertility.
- Measures of Population Growth.

Contents:

UNIT I:

Introduction and sources of collecting data on vital statistics, errors in the census, and registration data. Measurement of population, rate, and the ratio of vital events.

UNIT II: Measurements of Mortality

Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR), and Standardized Death Rates. Stationary and Stable population, Central Mortality Rates, and Force of Mortality.

UNIT III: Life Tables

Life(Mortality) Tables: Assumption, description, construction of Life Tables, and Uses of Life Tables.

UNIT IV: Measurements of Fertility

Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR), and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR), and Net Reproduction Rate (NRR).

PRACTICAL/LAB WORK

List of Practical:

1. To calculate CDR and Age Specific death rate for a given set of data.
2. To find a standardized death rate by (i) Direct method and (ii) Indirect method.
3. To construct a complete life table.
4. To fill in the missing entries in a life table.
5. To calculate CBR, GFR, SFR, TFR for a given set of data.
6. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
7. Calculate GRR and NRR for a given set of data and compare them.

SUGGESTED READINGS:

1. Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
2. Croxton, Fredrick, E. Cowden, Dudley J. and Klein, S. (1973). Applied General Statistics, 3rd Ed., Prentice Hall of India Pvt. Ltd.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, 9thEd., World Press.
4. Keyfitz, N. and Beekman,J.A. (1985). Demography through Problems. S-Verlag, New York.
5. Mukhopadhyay, P. (1999). Applied Statistics, Books and Allied (P) Ltd.

Discipline Specific Elective for B. Sc. (H) Statistics

Category-V

DISCIPLINE SPECIFIC ELECTIVE COURSE-2A: STATISTICALCOMPUTING USING C PROGRAMMING

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Computing Using C Programming	**4**	**3**	**0**	**1**	**Basic Knowledge of Computer**	

Learning Objectives:

The learning objectives include:

- To understand computer programming and its roles in problem solving.
- To understand basic data structures and develop logics which will help them to create well-structured programs using C language
- Learning the basic programming language will help students to easily switch over to any other language in future.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Various data types, operators, library functions, Input/Output operations.
- Decision making and branching and looping.
- Arrays, Character and strings.
- User- defined functions, recursive functions.
- Storage class of Variables
- Pointers and Structure
- Pre-processors: Macro substitution, macro with argument
- File inclusion in C, I/O operations on files.

SYLLABUS OF DSE- 2A

Theory

UNIT I **(6 hours)**

Introduction to C

History and importance of C. Components, basic structure programming, character set, C tokens, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data.

UNIT II **(9 hours)**

Expressions and I/O functions

Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement and conditional operators, precedence of operators in an expression. Managing input and output from the standard devices.

UNIT III **(12 hours)**

Branching and Arrays

Decision making and branching - if…else, nesting of if…else, else if ladder, switch. Looping in C: for, while, do…while, jumps in and out of loops.

Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

UNIT IV **(9 hours)**

Functions and Storage class

User- defined functions: definition of functions, return values and their types, function prototypes and calls. Category of Functions and recursive function. Passing arrays to functions, Storage class of Variables.

UNIT V **(9 hours)**

Pointers, Macros and Files

Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, functions returning pointers. Introduction of structure. Pre-processors: Macro substitution, macro with argument, file inclusion in C. Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files-fscanf and fprintf functions.

PRACTICAL – 30 Hours

List of Practicals:

1. Roots of a quadratic equation (with imaginary roots also)
2. Sorting of an array and hence finding median
3. Mean, Median and Mode of a Grouped Frequency Data
4. Variance and coefficient of variation of a Grouped Frequency Data
5. Preparing a frequency table
6. Value of n! using recursion
7. Random number generation from exponential, normal (using CLT) and gamma distribution calculate sample mean and variance.
8. Matrix addition, subtraction, multiplication, Transpose and Trace
9. Fitting of Binomial distribution and apply Chi-square test for goodness of fit
10. Chi-square contingency table
11. t-test for difference of means
12. Paired t-test
13. F-ratio test
14. Multiple and Partial correlation.
15. Compute ranks and then calculate rank correlation(without tied ranks)
16. Fitting of lines of regression

Essential Readings:

1. Balagurusamy, E. (2019): Programming in ANSI C, 8th Edition, Tata McGraw Hill.
2. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata McGraw Hill
3. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2nd Edition,Prentice Hall.

Suggestive Readings:

1. Yashavant Kanetkar (2020) : Let Us C, 18th Edition, BPB Publications
2. Greg Perry and Dean Miller (2015) : C Programming Absolute Beginner's Guide, 3rd Edition, Pearson Publications

DISCIPLINE SPECIFIC ELECTIVE-2B: ADVANCED TECHNIQUES OF SAMPLE SURVEYS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title and code	*Credits*	*Credit distribution of the course*			*Eligibility criteria*	*Pre-requisite of the course (if any)*
		Lectures	**Tutorials**	**practicals**		

Advanced Techniques of Sample Surveys	**4**	**3**	**0**	**1**	**B.Sc.(H) Statistics Sem III**	**STAT-DSC- 7**

Learning Objectives:

The learning objectives include:

- Advanced techniques relating to stratified and systematic sampling, ratio and regression methods of estimation.
- Study cluster and two-stage sampling when the population is divided into groups.
- Study about the errors due to factors other than the inductive process of inferring about the population from a sample.

Course Learning Outcomes:

After completion of this course, students should have developed a clear understanding of

- Post Stratification, determination of optimum number of strata, construction of strata
- Circular systematic sampling
- Ratio and Regression method of estimation under Superpopulation model
- Cluster Sampling
- Two-stage sampling
- Non-sampling errors

SYLLABUS OF DSE-2B

UNIT I **(15 Hours)**

Stratified Sampling: Post Stratification, effect of increasing the number of strata, determination of optimum number of strata, construction of strata (Neyman allocation, Proportional allocation and approximate method by Dalenius and Hodges), method of collapsed strata, allocation requiring more than 100% sampling.

Systematic Sampling: Circular systematic sampling, Yates' and Cochran method of estimation of sampling variance.

UNIT II **(15 Hours)**

Superpopulation model, Ratio method of estimation under superpopulation model, regression method of estimation under superpopulation model.

Cluster Sampling (equal sized clusters): Estimation of population mean and its variance, efficiency of cluster sampling, effect of formation of clusters randomly, efficiency of cluster sampling in terms of intra-class correlation, estimation of efficiency, optimum size of cluster.

UNIT III **(15 Hours)**

Two-stage sampling/sub-sampling (Equal first stage units): Estimation of population mean and its variance, Estimator of variance of sample mean, allocation of sample to two-stages, comparison of two-stage with one-stage sampling.

Non-sampling errors: Classification of non-sampling errors, types of non-sampling errors, bias due to non-response, Hansen and Hurwitz technique, comparison of Hansen and Hurwitz technique with SRS under a cost constraint

Practical Work based on:

1. Dalenius and Hodges method of construction of strata
2. Determination of optimum number of strata
3. Cluster sampling
4. Circular systematic sample
5. Ratio method of estimation under superpopulation model
6. Regression method of estimation under superpopulation model
7. Two-stage sampling

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Suggested Readings:

1. Cochran, W.G. (2011): *Sampling Techniques* (3rd Ed.), Wiley Eastern John Wiley and Sons..
2. Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., Asok, C.(1984). *Sampling Theories of Survey with Application*, IOWA State University Press and Indian Society of Agricultural Statistics.
3. Gupta, S.C. and Kapoor, V.K. (2007): *Fundamentals of Applied Statistics*, Sultan Chand and Sons.
4. Singh, D. and Chaudhary, F. S. (2015): *Theory and Analysis of Sample Survey Designs*.
5. Murthy M.N. (1977): *Sampling Theory & Statistical Methods*, Statistical Pub. Society, Calcutta.
6. Des Raj and Chandhok P. (1998): *Sample Survey Theory*, Narosa Publishing House.
7. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2001): *Fundamentals of Statistics* (Vol.2), World Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

REMARK 1: DSE-2 for B.Sc. (Math. Sc.) to be uploaded tomorrow