BANGALORE UNIVERSITY

Regulations and Syllabus
for
STATISTICS
in
Three Year BSc Course (CBCS 2017)

Eligibility

1. Only those candidates who have passed Pre-University course or an equivalent course with Mathematics/Business Mathematics/ Basic Mathematics/Applied Mathematics as one of the optional subjects are eligible to take Statistics as one of the optional subjects in BSc course.
2. Any student taking Statistics as one of the optional subjects in the B.Sc. course shall take Mathematics as another optional subject.

Scheme of Instruction/ Examination

1. The subject of Statistics in this course has to be taught by MSc/MA degree holders in Statistics / Applied Statistics.
2. The theory question paper for each paper shall cover all the topics in the pertaining syllabus with proportional weightage to the number of hours of instruction prescribed.
3. The practicals are to be conducted in batches as per the University norms for the faculty of science (normally 10 students per batch per teacher).
4. Two teachers are to be assigned for each batch with not more than 20 students for giving instructions, supervision, and correction of records.
6. It is expected that each student collects and uses real life data for the practical classes.
7. Students are required to use Statistical software, run the programmes, and enclose computer outputs to the practical records in the case of computer based practicals.
8. Maximum marks for each record in the examination is 5.
9. Study tour for the students is strongly recommended to gain practical knowledge of applications of Statistics in Industries/Agriculture/Medical field.

Scheme for theory and practicals

Sem.	Code number	Title of the paper (Theory / Practical)	Lecture/ Practical hours per week	Duration of exam	IA marks	Maximum marks	Total	Credits
I	ST 101	Basic Statistics-I	04	03	30	70	100	2
	ST 102	Practical –I	03	03	15	35	50	1
II	ST 201	Basic Statistics- II	04	03	30	70	100	2
	ST 202	Practical –II	03	03	15	35	50	1
III	ST 301	Statistical Inference-I	04	03	30	70	100	2
	ST 302	Practical –III	03	03	15	35	50	1
IV	ST401	Statistical Inference-II	04	03	30	70	100	2
	ST 402	Practical –IV	03	03	15	35	50	1
V	ST 501	Sampling Theory and Statistical Quality Control	03	03	30	70	100	2
	ST502	Practical –V	03	03	15	35	50	1
V	ST 503	Design of Experiments and Demography	03	03	30	70	100	2
	ST504	Practical –VI	03	03	15	35	50	1
VI	ST 601	Applied Statistics	03	03	30	70	100	2
	ST602	Practical –VII	03	03	15	35	50	1
VI	ST 603	Operational research	03	03	30	70	100	2
	ST604	Practical –VIII	03	03	15	35	50	1

Total credits: 24

STATISTICS

FIRST SEMESTER

4 hours lecture + 3 hours practical per week
(Theory 2 credits + Practical 1 credit)

ST 101: BASIC STATISTICS – I

(52 hours : 2 credits)

Unit 1

Organization and presentation of data: Meaning, importance, and scope of Statistics. Types of data:Primary and secondary data. Types of measurements: Nominal, ordinal, ratio, and interval. Classification and tabulation. Construction of frequency distribution.Graphical representation: Frequency curve, Ogives, histogram. **8 hrs**

Unit 2

Univariate data analysis: Measures of location: Arithmetic mean, median, mode, geometric mean, harmonic mean and their properties. Quantiles: quartiles, deciles, percentiles. Absolute and relative measures of dispersion: range, standard deviation, mean deviation, quartile deviation, coefficient of variation and their properties. Moments:Raw and central moments, properties., and relationship between them. Skewness and kurtosis: concept, measures, and properties. **16 hrs**

Unit 3

Bivariate data analysis: Bivariate data, Scatter diagram,Correlation, Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient. Concept of errors, Principle of least squares. Simple linear regression and its properties. Fitting linear regression line and coefficient of determination. **10 hrs**

Unit 4

Multivariate data analysis: Multiple linear regression, multiple and partial correlation coefficients. Residual error variance. Coefficient of determination. **6 hrs**

Unit 5

Elements of probability: Random experiments, sample space,events, related results. Classical, empirical, and axiomatic approaches to probability. Properties of probability.Illustrations and applications. Addition thoerem. Conditional probability, independence of events.Law of total probability. Bayes theorem and applications. **12 hrs**

ST 102: PRACTICAL – I
List of Assignments

(30 hours : 1 credit)

(Demonstration using MS Excel)

1. Construction of frequency distribution andgraphical representation.
2. Measures of central tendency I
3. Measures of central tendency II (Positional averages & Partition values).
4. Measures of dispersion (Range,QD , MD,SD,and CV).

5. Moments, skewness, and kurtosis for a frequency distribution.
6. Correlation and regression for ungrouped data and Spearman's rank correlation coefficient.
7. Correlation and regression for grouped data
8. Analysis of trivariate data.
9. Computation of probabilities using combinatorial methods.
10. Application of addition rule, conditional probability, Bayes formula.

Text Books

1. Croxton, F.E, Cowden, D.J., and Klein, S. (1973). *Applied General Statistics*, 3/e, Prentice Hall Inc., New Jersey, USA.
2. Freund, J.E. and Walpole, R.E. (1987). Mathematical Statistics, 4/e,Prentice Hall Inc., New Jersey, USA.
3. Goon, A.M., Gupta, M.K., and Das Gupta, B. (1991). *Fundamentals of Statistics, Vol. I,* World Press, Calcutta.
4. Medhi, J. (1992).*Statistical Methods: An introductory Text*, New Age International, New Delhi.
5. Montgomery, D.C. and Runger, G.C. (2013). *Applied Statistics and Probability for Engineers*, Wiley India, New Delhi.

References

1. Anderson, T.W. and Sclove, S.L. (1978).*An Introduction to the Statistical Analysis of Data*, Houghton Mifflin and Co, New York.
2. Cooke, H.D., Craven, A.H., and Clarke, G.M. (1982): *Basic Statistical Computing*, Chapman and Hall, New York.
3. Mood, A.M., Graybill, F.A., and Boes, D.C. (1974): *Introduction to the Theory of Statistics*, McGraw Hill, New York.
4. Ross, S.M (2003).*Introduction to Probability Models*, 10/e, Academic Press, UK.
5. Snedecor, G.W. and Cochran, W.G. (1967). *Statistical Methods*, Iowa StateUniversity Press, USA.
6. Spiegel, M.R. (1967).*Theory and Problems of Statistics*, Schaum's PublishingSeries, London.

STATISTICS

SECOND SEMESTER

4 hours lecture +3 hours practical per week
(Theory 2 credits + Practicals 1 credit)

ST 201: BASIC STATISTICS – II

(52 hours : 2 Credits)

Unit 1

Random variables and expectation (Univariate): Distribution function, Discrete and continuous random variables, Probability mass and density functions- properties and illustrations. Expectation of a random variable and algebra of expectations and related results. Moments and moment generating function, properties and applications. Transformation of random variables. **9 hrs**

Unit 2

Discrete probability distributions: Discrete uniform, Bernoulli, binomial, Poisson, geometric, negativebinomial, and hypergeometric distributions – mean, variance, moments, and MGF. Recursive relations for moments of binomial and Poisson distributions. Approximations of binomial, negative binomial and hyper geometric distributions. **12 hrs**

Unit 3

Continuous probability distributions: Uniform, gamma, beta, exponential, Normal, and Cauchy distributions – mean, variance, moments, MGF, and properties. **16 hrs**

Unit 4

Random variables and expectation (Bivariate): Bivariate random variables, joint, marginal, and conditional distributions. Independence of random variables. Moments, covariance, and correlation coefficient. Properties of expectations of bivariate random variables. Mean and variance of linear combination of random variables. MGF of sum of independent random variables. **9 hrs**

Unit 5

Limit theorems: Chebyschev's inequality – proof and its role in approximating probabilities. Convergence of binomial, Poisson, gamma distributions to Normal distribution. Statement of central limit theorem and its applications. **6 hrs**

ST 202: PRACTICAL –II

List of Assignments

(30 hours : 1 credit)

(Demonstration using MS Excel and R software)

1. Univariate probability distributions: Expectation, moments, skewness, and kurtosis.
2. Bivariate probability distributions: Moments and correlation coefficient.
3. Applications of binomial distribution and fitting binomial distribution.

4. Applications of Poisson distribution and its fitting.
5. Computation of probabilities based on negative binomial, geometric, hyper geometric and discrete uniform distributions.
6. Applications of Normal distribution.
7. Fitting normal distribution.
8. Computation of probabilities based on rectangular and exponential distributions.
9. Applications of Chebyschev's inequality.
10. Applications of the central limit theorem.

Text Books

1. Goon A.M., Gupta, M.K., Das Gupta, B. (1991).*Fundamentals of Statistics,*Vol.I, World Press, Calcutta.
2. Hogg, R. V. and Craig, A.T. (1995).*Introduction to Mathematical Statistics,* 5/e, Prentice Hall, New Jersey, USA.
3. Medhi, J. (1992).*Statistical Methods: An introductory text,* New Age International, New Delhi.
4. Mukhopadhyay, P.(2015): *Mathematical Statistics,* Books and Allied Pvt Ltd., Kolkata.
5. Spiegel, M.R. (2001).*Probability and Statistics*, 4/e, Schaum's Outline Series, McGraw Hill, London.
6. Walpole, R.E., Myers, R.H., and Myers, S.L. (2017). *Probability and Statistics for Engineers and Scientists,* 9/e, Pearson, New Delhi.

References

1. Bhattacharya, G. K. and Johnson, R.A. (1986): Statistical Concepts and Methods, John Wiley, New York.
2. Dudewicz, E.J. and Mishra, S.N.(1980). *Modern Mathematical Statistics,* John Wiley, New York.
3. Montgomery, D.C. and Runger, G.C. (2013). *Applied Statistics and Probability for Engineers,* Wiley India, New Delhi.
4. Rohatgi, V.K. and Saleh, A.K. Md. E. (2002). *An Introduction to Probability Theory and Mathematical Statistics*, 3/e, John Wiley, New York.
5. Ross, S.M (2003).*Introduction to Probability Models*, 10/e, Academic Press, UK.

STATISTICS

THIRD SEMESTER

4 hours lecture + 3 hours practical per week
(Theory 2 credits + Practicals 1 credit)

ST 301: STATISTCAL INFERENCE - I

(52 hours : 2 credits)

Unit 1

Sampling distributions: Population and sample. Sampling distribution and standard error. Sampling distribution of mean, variance. Chi-square, t, and F distributions – mean, variance, M.G.F, and properties. **10 hrs**

Unit 2

Point estimation: Families of distributions - location and scale families. Single parameter exponential family. Point estimation. Concepts of estimator and estimate. Criteria for estimators: Unbiasedness, consistency. Invariance property of consistent estimators. Efficiency andrelative efficiency. Mean square error as a criterion for comparing estimators. Sufficient statistic. Statement of Neyman - Factorization theorem. Fisher information function. Statement of Cramer - Rao inequality and its applications. Minimum variance unbiased estimator and minimum bound estimator**.** **20 hrs**

Unit 3

Methods of point estimation: Maximum likelihood and method of moment estimation. Properties of maximum likelihood and moment estimators and examples. **6 hrs**

Unit 4

Interval estimation: Confidence interval, confidence coefficient, shortest confidence interval. Method of constructing confidence intervals using pivotal quantity. Construction of confidence intervals for mean, difference of two means, variance and ratio of variances,proportion, difference of two proportions, and correlation coefficient. **8 hrs**

Unit 5

Simulation: Introduction to simulation. Monte Carlo method. Generation of random observationsfrom uniform, exponential, Normal, Cauchy, binomial, Poisson distributions. Simple illustrations. **8 hrs**

ST 302: PRACTICAL III

List of Assignments

(30 hours : 1 credit)

(Demonstration using MS Excel and R Software)

1. Drawing random samples using random number tables .
2. Point estimation of parameters and obtaining estimates of standard errors.

3. Comparison of estimators by plotting mean square error.
4. Computing maximum likelihood estimates -1
5. Computing maximum likelihood estimates - 2
6. Computing moment estimates
7. Constructing confidence intervals based on large samples.
8. Constructing confidence intervals based on small samples.
9. Generating random samples from discrete distributions.
10. Generating random samples from continuous distributions.

Text Books

1. Goon A.M., Gupta, M.K., Das Gupta, B. (1991).*Fundamentals of Statistics*,Vol.I, World Press, Calcutta.
2. Hogg, R. V. and Craig, A.T. (1995).*Introduction to Mathematical Statistics*, 5/e, Prentice Hall, New Jersey, USA.
3. Medhi, J. (1992).*Statistical Methods: An introductory text*, New Age International, New Delhi.
4. Montgomery, D.C. and Runger, G.C. (2013). *Applied Statistics and Probability for Engineers*, WileyIndia, New Delhi.
5. Mukhopadhyay, P.(2015): *Mathematical Statistics*, Books and Allied (P) Ltd., Kolkata.
6. Spiegel, M.R. (2001).*Probability and Statistics*, 4/e, Schaum's Outline Series, McGraw Hill, London.
7. Walpole, R.E., Myers, R.H., and Myers, S.L. (2017). *Probability and Statistics for Engineers and Scientists*, 9/e, Pearson, New Delhi.

References

1. Bhattacharya, G. K. and Johnson, R.A. (1986): *Statistical Concepts and Methods*, John Wiley, New York.
2. Casella, G. and Berger, R.L. (1990). *Statistical Inference*, Duxbury Press, Belmont, California, USA. (2nd Edition).
3. Dudewicz, E.J. and Mishra, S.N.(1980). *Modern Mathematical Statistics*, John Wiley, New York.
4. Rohatgi, V.K. and Saleh, A.K. Md. E. (2002). *An Introduction to Probability and Statistics*, 2/e, John Wiley, New York.
5. Ross, S.M (2003). *Introduction to Probability Models*, 10/e, Academic Press, UK.

STATISTICS

FOURTH SEMESTER

4 hours lecture + 3 hours practical per week
(Theory 2 credits + Practicals 1 credit)

ST 401: STATISTICAL INFERENCE - II

(52 hours : 2 credits)

Unit 1

Introduction to tests of hypotheses: Statistical hypotheses- null and alternative, simple and composite hypotheses. Type-I and Type-II errors, test functions. Randomized and nonrandomized tests. Size, level of significance, power function, power of tests. Critical region.p-value and its interpretation. Illustrative examples. Most powerful (MP) test. Statement of Neyman – Pearson lemma and its applications. **12 hrs**

Unit 2

Tests of significance I: Large and small sample tests of significance.Tests for single mean, equality of two means, single variance, and equality of two variances for normal populations. Tests for proportions. **12 hours**

Unit 3

Tests of significance II: Tests for simple, partial,and multiple correlation coefficients and regression coefficients. Fisher's Z-transformation and its applications. Analysis of categorical data: contingency tables, tests for the independence andassociation of attributes. Chi-square tests for independence of attributes and goodness of fit. **12 hrs**

Unit 4

Nonparametric tests: Introduction to nonparametric tests. Run test for randomness. Sign test and Wilcoxon signed rank test for one and paired samples. Run test, median test, and Mann-Whitney-Wilcoxon test for two sample problems. Test for independence based on Spearman's rank correlation coefficient. **10 hrs**

Unit 5

Sequential tests: Need for sequential tests, Wald's SPRT for binomial proportion and Normal population mean when variance is known. **6 hrs**

ST 402: PRACTICAL – IV

List of Assignments

(30 hours : 1 credit)

(Demonstration of practicals using MS-Excel)

1. Evaluation of probabilities of Type-I and Type-II errors and powers of tests.
2. MP test for parameters of binomial and Poisson distributions.
3. MP test for the mean of a normal distribution and power curve.
4. Tests for mean, equality of means when variance is (i) known, (ii) unknown

under normality (small and large samples)
5. Tests for single proportion and equality of two proportions.
6. Tests for variance and equality of two variances under normality
7. Tests for correlation and regression coefficients.
8. Tests for the independence of attributes, analysis of categorical data and tests for the goodness of fit.(For uniform, binomial and Poisson distributions)
9. Nonparametric tests.
10. SPRT for binomial proportion and mean of a normal distribution.

Text Books

1. Chandra,T. K. and Chatterjee, D. (2005). *A First Course in Probability*, Narosa Publishing House, New Delhi..
2. Hogg, R. V. and Craig, A.T. (1995).*Introduction to Mathematical Statistics,* 5/e, Prentice Hall, New Jersey, USA.
3. Lehmann, E. L. and Romano, J. P. (2005). *Testing Statistical Hypotheses,* 2/e, John Wiley, NewYork.
3. Montgomery, D.C. and Runger, G.C. (2013). *Applied Statistics and Probability for Engineers*, Wiley India, New Delhi.
4. Mukhopadhyay, P.(2015): *Mathematical Statistics*, Books and Allied (P) Ltd., Kolkata.
5. Walpole, R.E., Myers, R.H., and Myers, S.L. (2017). *Probability and Statistics for Engineers and Scientists,* 9/e, Pearson, New Delhi.

References

1. Bhattacharya, G. K. and Johnson, R.A. (1986): Statistical Concepts and Methods, John Wiley, New York.
2. Dudewicz, E.J. and Mishra, S.N.(1980). *Modern Mathematical Statistics*, John Wiley, New York.
3. Rohatgi, V.K. and Saleh, A.K. Md. E. (2002). *An Introduction to Probability Theory and Mathematical Statistics*, 2/e, John Wiley, New York.

STATISTICS

FIFTH SEMESTER

6 hours of lecture + 6 hours of practical per week
(Theory: 4 credits + Practicals: 2 credits)

ST 501: SAMPLING THEORY AND STATISTICAL QUALITY CONTROL

(39 hours : 2 credits)

Unit 1

Introduction to sampling theory: Need for sampling.Complete enumeration Vs sample surveys. Probability and non-probability sampling. Methods of drawing random samples. Survey methods, principal steps in a sample survey, planning, execution, analysis, and reporting stages. Sampling and non-sampling errors. **5 hrs**

Unit 2

Simple random sampling (SRS): Sampling with and without replacement. Unbiased estimators of population mean and total. Derivation of sampling variances. SRS for proportions. Derivation of the sampling variances andstandard errors. Confidence limits. Determination of sample size. Advantages and limitations of SRS. **8 hrs**

Unit 3

Stratified and systematic sampling: Stratified random sampling: Need for stratification, advantages, and limitations. Unbiased estimators of population mean and total. Derivation of the variance of the estimators and their estimation. Proportional, optimum and Neyman allocations. Comparison of variances with SRSWOR. Estimation of gain in precision due to stratification.

Linear systematic sampling, its advantages and limitations. Estimation of mean, total and variance of the estimators. Comparison with SRSWOR .Circular systematic sampling. **10 hrs**

Unit 4

Process control: Introduction to statistical quality control (SQC), aims and objectives. Chance and assignable causes of variation. Process control and product control. Control charts and basis for their construction. Action and warning limits. Various tools of SQC. Rational subgroups.Derivation of control limits, basis, construction, and interpretation of mean, range, and standard deviation charts, np-chart, p-chart, stabilized p-chart, c-chart and u-chart. Criteria for detecting lack of control. Process capability study**:** Natural tolerance limits and specification limits, process capability,PCR and interpretation. **10 hrs**

Unit 5

Product control: Lot acceptance sampling- Sampling inspection, 100 percent inspection and rectifying inspection. AQL, LTPD, Producer's risk and consumer's risk. Acceptance sampling plans – single and double sampling plans by attributes- Derivation of OC, AOQ, ASN, and ATI, functions. **6 hrs**

ST 502: PRACTICAL – V

List of Assignments

(30 hours : 1 credit)

1. Drawing of random sample under SRSWR and SRSWOR from a given population and estimation of the mean and total and the standard errors of the estimators. Construction of confidence intervals.
2. Estimation of the proportion, total, and the standard errors of the estimatorsbased on a random sample under SRSWR and SRSWOR .
3. Stratified random sampling.
4. Systematic sampling.
5. $\overline{X}$ – R charts. (Standard values known and unknown).
6. $\overline{X}$ – s charts. (Standard values known and unknown).
7. np and p charts. (Standard values known and unknown).
8. c and u charts. (Standard values known and unknown).
9. Drawing OC, AOQ, ASN, and ATI curves for single sampling plan.
10. Drawing OC, AOQ, ASN, and ATI curves for double sampling plan.

Text Books

1. Goon A.M., Gupta, M.K., Das Gupta, B. (1991).*Fundamentals of Statistics*,Vol.I, World Press, Calcutta.
2. Grant, E.L. and Leavenworth, R. S. (1996). *Statistical Quality Control*. 7th edition, McGrawHill, New York.
3. Mahajan, M. (2001).*Statistical Quality Control*, Dhanpat Rai & Co. (P) Ltd. New Delhi.
4. Montgomery, D.C. (2013). *Introduction to Statistical Quality Control*, (Wiley Int. Edn.)
5. Cochran,W. G. (2007). *Sampling Techniques*. 3/e, John Wiley and Sons, New York.
6. Alwan, L. C. (2000). *Statistical Process Analysis*, McGraw Hill, New York**.**

References

1. John, S.O. and Followell, R. F. (1990). Statistical Process Control. (East West Press, India.
2. Mukhopadhyay, P (1996). Applied Statistics. Calcutta Publishing House.
3. Des Raj and Chandok, P. (1998). *Sampling Theory*, Narosa, New Delhi.
4. Mukhopadhyay, P. (2015): *Mathematical Statistics*, Books and Allied (P) Ltd., Kolkata.
5. Murthy, M.N. (1977). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
6. Sampath, S. (2006). *Sampling Theory and Methods*, 2/e, Narosa, New Delhi.

ST 503: DESIGN AND ANALYSIS OF EXPERIMENTS

(39 hours : 2 credits)

Unit 1

Analysis of variance: Meaning and assumptions. Fixed, random and mixed effect models. Analysis of variance of one-way and two-way classified data with and without interaction effects. Multiple comparison tests: Tukey's method, critical difference. **10 hrs**

Unit2

Experimental designs: Principles of design of experiments. Completely randomized, randomized block, and Latin square designs (CRD, RBD, and LSD) -layout formation and the analysis using fixed effect models. **10 hrs**

Unit 3

Efficiency of a design and missing plot technique: Comparison of efficiencies of CRD, RBD, and LSD . Estimation of single missing observation in RBD and LSD and analysis. **5 hrs**

Unit 4

Factorial experiment: Factorial experiment: Basic concepts, main effects, interactions, and orthogonal contrasts in $2^2$and 2^3 factorial experiments. Yates' method of computing factorial effects total. Analysis and testing the significance of effects in $2^2$and 2^3 factorial experiments in RBD**.** **8 hrs**

Unit 5

Confounding: Need for confounding. Complete and partial confounding in a 2^3 factorial experiment in RBD - layout and its analysis. **6 hrs**

ST 504: PRACTICAL – V

List of Assignments

(30 hours : 1 credit)

(Demonstration of practicals using MSExcel)

1. ANOVA for one way classified data.
2. ANOVA for two way classified data.
3. Analysis of CRD.
4. Analysis of RBD.
5. Analysis of LSD.
6. Missing plot techniques in RBD and LSD
7. Analysis of 2^2 factorial experiment using RBD layout.
8. Analysis of 2^3 factorial experiment using RBD layout.
9. Analysis of 2^3 factorial experiment using RBD layout. (Complete confounding)
10. Analysis of 2^3 factorial experiment using RBD layout. (Partial confounding)

Text Books

1. Goon A.M., Gupta, M.K., Das Gupta, B. (1991).*Fundamentals of Statistics*,Vol.I, World Press, Calcutta.
2. Montgomery, D.C. (2014). *Design and Analysis of Experiments*, Wiley. New York.
3. Joshi, D. D. (1987).*Linear Estimation and Design of Experiments*, New Age International (P) Limited, New Delhi.

References

1. Cochran, W.G. and Cox, G. M. (1992).*Experimental Designs*, John Wiley and Sons, New York.
2. Mukhopadhya, P.(2015): *Mathematical Statistics*, Books and Allied (P) Ltd., Kolkata.

STATISTICS

SIXTH SEMESTER

6 hours lecture + 6 hours practical per week
(Theory 4 credits + Practicals 2 credits)

ST 601: APPLIED STATISTICS

(39 hours : 2 credits)

Unit 1

Time series analysis: Components of time series. Additive and multiplicative models. Measurements of trend by moving averages and by least squares. Construction of seasonal indices by simple averages and ratio to moving averages. **8 hrs**

Unit 2

Index numbers: Introduction. Price and quantity index numbers. Construction of index numbers: Simple and weighted methods. Tests for consistency of index numbers. Consumer price index. Problems involved in the construction of general and consumer price index numbers. Uses and limitations. **7 hrs**

Unit 3

Demography: Sources of demographic data. Measurement of mortality: Crude, specific, and standardized death rates. Infant and maternal mortality rates. Measurement of fertility: crude, age specific general, and total fertility rates. Reproduction rates. Life table: Components of a life table, force of mortality, and expectation of life. Construction of a life table. Uses of a life table. **10 hrs**

Unit 4

Clinical trials: Introduction, therapeutic and prophylactic trails. Observational, crosssectional, prospective, retrospective, and randomized controlstudies.Odds ratio and its confidence interval. Relative risk and its confidence interval. Diagnostic efficacy. Application of Bayes theorem. Sensitivity, specificity, false negative andfalse positive rates. Receiver operating characteristic (ROC) curve. Body mass index. **7 hrs**

Unit 5

Official Statistics and national income: History of Indian Statistical System. Pre and post independence era .CSO NSSO and their activities. National income. Basic concepts of GNP, GDP, NNP. National Income at factor cost – NDP, per capita income. Real national income. Methods of estimating national income. Problems in estimating national income. Uses of national income statistics. National accounts statistics of CSO. **7 hrs**

ST 602: PRACTICALS - VII

List of Assignments

(30 hours : 1 credit)

1. Time series 1: Measurement of trend.
2. Time series 2: Measurement of seasonal variation .
3. Construction of index numbers and consumer price index numbers.
4. Tests for consistency of index numbers.

5. Vital Statistics 1: Computation of various mortality rates.
6. Vital Statistics 2: Computation of various fertility rates.
7. Vital Statistics 3: Life table construction and computation of reproduction rates.
8. Clinical trials 1: (Odds ratio, relative risk, and confidence interval)
9. Clinical trials 2: (ROC curve and computation of various rates)
10. National income.

Text Books

1. Goon A.M., Gupta, M.K., Das Gupta, B. (1991). *Fundamentals of Statistics*, Vol. II, World Press, Calcutta.
2. Montgomery, D.C. and Runger, G.C. (2013). *Applied Statistics and Probability for Engineers,* Wiley India, New Delhi.
3. Sundar Rao, P.S.S. and Richard, J. (2012). *Introduction to Biostatistics and Research Methods*, 5/e, Prentice Hall of India, New Delhi.
4. Saluja, M. R. (1972). *Indian Official Statistical Systems,* Statistical Publishing Society, Calcutta.

References

1. CSO (1980). *National Accounts Statistics* - Sources and Health, Govt. of India, New Delhi.
2. UNESCO: Principles for Vital Statistics Systems. Series M -12.
3. Sen, A. (1997). Poverty and Inequality, Stanford University Press, USA.
4. Mukhopadhyay, P. (2015). *Applied Statistics,* Books and Allied Pvt Ltd., Kolkata.

ST 603: OPERATIONS RESEARCH

(39 hours : 2 Credits)

Unit 1

Introduction to OR and LPP: Definition and scope of operations research (OR). Modeling and solution. Linear programming problem (LPP): Definition, standard and canonical forms. Formulation of LPP. Basic feasible solutions, degenerate and non degenerate solutions. Graphical solution and simplex algorithm for solving an LPP.Artificial variable, Charnes' Big- M Method. Criteria for unbounded, multiple, andinfeasible solutions. Concept of duality in LPP. **14 hrs**

Unit 2

Transportation and assignment problems: Mathematical formulation of transportation problem. Existence of feasible solution. Finding initial basic feasible solution: North - West corner rule and Vogel's method. Test for optimality. Transportation algorithm. Problem of degenerate solution. Unbalanced transportation problem.

Mathematical formulation of assignment problem and Hungarian algorithm. Unbalanced assignment problem.

8 hrs

Unit 3

Game Theory: Basic concepts of game theory. Two-person zero sum game. Pure and mixed strategies. Maximin–Minimax principles, Games with saddle point. Principle of dominance. Games without saddle point. Mixed strategies. Determination of optimum solution for a 2x2 game. Solution by graphical method for 2xn and mx2 games. **5 hrs**

Unit 3

Inventory and replacement theory: Description of an inventory system. Inventory costs. Demand, lead time, and reorder level. Inventory models. EOQ model with and without shortages.

Need for replacement. Replacement policy for items which deteriorate with time. Optimum policy with discrete and continuous time. Group replacement policy. **8 hrs**

Unit 5

Queuing theory: Characteristics of a queuing system. Steady state system size distribution in M/M/1 queuing system (only statement). Waiting time distributions. Little's formula, measures of effectiveness, derivation of expressions for expected queue length, and expected system size(length) and expected waiting times. Description of M/M/C queuing system. **4 hrs**

604: PRACTICAL - VIII

List of Assignments

(30 hours : 1 credit)

(Demonstration of practicals using TORA software)

1. Formulation of linear programming problem (LPP) - graphical solution.
2. Solution of LPP - simplex algorithm - 1
3. Solution of LPP - simplex algorithm - 2
4. Transportation problems - 1 (IBFS)
5. Transportation problems - 2 (OBFS)
6. Assignment problems
7. Game theory problems.
8. Inventory problems
9. Replacement problems
10. Queuing problems

Text Books

1. Churchman, C.W, Ackoff, R.L., and Arnoff, E.L. (1957). *Introduction to Operations Research*, John Wiley and Sons, New York.
2. Kanthi Swaroop, Manmohan and P.K. Gupta (2012). *Operations Research*, Sultan Chand, New Delhi.
3. Kalavathy, S.(2004). *Operations Research*, Vikas Publishing House Pvt. Ltd. New Delhi.
4. Shenoy, G.V., Srivastava, U. K., and Sharma, S.C. (2009). *Operations Research for Management, 2/e*, New Age International, New Delhi.

References

1. Mustafi, C.K. (2006). *Operations Research: Methods and Practice*, 3/e, New Age International, New Delhi.
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