

## Semester 6

### DEPARTMENT OF STATISTICS

#### B. Sc. (H) Statistics

##### Category I

###### **DISCIPLINE SPECIFIC CORE COURSE – 16: TESTING OF HYPOTHESIS**

###### **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		
Testing of Hypothesis	4	3	0	1	Class XII pass with Mathematics	Basic knowledge of sampling distributions

##### **Learning Objectives**

The learning objectives of this course are to introduce:

- Hypothesis testing as a statistical procedure for testing whether chance is a plausible explanation of a random experiment
- The logic of hypothesis testing with focus on theory and implementation of hypothesis testing with knowledge about types of error type, power and the correct computation and interpretation of p-values
- Use of nonparametric test as an alternative when assumptions of parameterization of distribution or the family itself is violated.
- Sequential Probability Ratio test with its entities like OC Curve, ASN etc.

##### **Learning Outcomes:**

After completing this course, students will develop a clear understanding of:

- The notion of statistical hypothesis test, error and its nature and the idea of acceptance and rejection region.
- Identify simple and composite hypothesis. Find critical region, size and power of the test.
- Apply Neymann-Pearson lemma to find most powerful test. Find UMP and UMPU test. Make use of likelihood ratio principle for testing of hypothesis
- Make distinction between parametric and nonparametric test. Identify suitable nonparametric test for both location and scale (Kolmogorov- Smirnov one sample and two sample tests, sign test, Wilcoxon signed rank test, run test. Median test, Kruskal-Wallis one-way analysis of variance by ranks, Friedman two way analysis of variance by ranks).
- Derive SPRT for test the parameters of normal distribution, binomial and Poisson distributions also find OC function, Average sample Number etc. of a SPRT.

## **SYLLABUS OF DSC-16**

### **Theory**

#### **UNIT I** **(15 hours)**

##### **Principles of test of significance**

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

#### **Unit II** **(10 hours)**

##### **Likelihood ratio test**

Likelihood ratio test and its application, properties of likelihood ratio tests (without proof).

#### **UNIT III** **(10 hours)**

##### **Sequential Probability Ratio Test**

Sequential Probability Ratio Test. Determination of stopping bounds A and B, OC and ASN functions of SPRT.

#### **UNIT IV** **(10 hours)**

##### **Non-Parametric tests**

Non-Parametric tests. Empirical distribution function, one sample and two-sample sign test. Wald-Wolfowitz run test. Run test for randomness, Median test, Wilcoxon-Mann-Whitney U-test. Kolmogorov-Smirnov one-sample test, Kruskal-Wallis's test.

### **PRACTICAL/LAB. WORK(30 hours):**

#### **List of Practical**

1. Type I and Type II errors
2. Most powerful critical region (NP Lemma)
3. Uniformly most powerful critical region
4. Unbiased critical region
5. Power curves of hypothesis tests.
6. Likelihood ratio test
7. Non Parametric test based on quantile and Empirical distribution
8. Test for location and scale both one and two samples
9. Test of Association for bivariate samples
10. SPRT for binomial, Poisson and Normal distribution
11. OC Curve and ASN function

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

#### **ESSENTIAL READINGS:**

- Goon, A.M., Gupta, M.K., and Dasgupta, B. (2005).: An Out Line of Statistical Theory, Volume 2, Third Edition.
- Gupta, S.C. and Kapoor, V.K.(2020): Fundamental of Mathematical Statistics, 12<sup>th</sup> Edn. Sultan Chand and Sons.

**SUGGESTIVE READINGS:**

- Hogg, R.V, McKean, J. and Craig, A.T. (2012): Introduction to Mathematical Statistics, 7th Edn. Pearson Education.
- Casella, G. and Berger, R.L. (2002): Statistical Inference. 2nd Edition, Duxbury Press, Pacific Grove.
- Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. McGraw-Hill.
- Lehmann, E. and Romano. J. (2005): Testing statistical hypotheses,3rd Edn. Springer, New York.

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

**DISCIPLINE SPECIFIC CORE COURSE –17: DESIGN OF EXPERIMENTS****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		
Design of Experiments	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions and linear models

**Learning Objectives**

The learning objectives include:

- To design and conduct experiments.
- To analyze and interpret data.

**Learning Outcomes:**

After completing this course, students will develop a clear understanding of:

- The fundamental concepts of design of experiments.
- Introduction to planning valid and economical experiments within given resources.
- Completely randomized design.
- Randomized block design.
- Latin square design.
- Balanced incomplete block design.
- Full and confounded factorial designs with two levels.
- Introduction to factorial designs at three levels.
- Fractional factorial designs with two levels

**SYLLABUS OF DSC-17****Theory****UNIT I****(13 hours)**

## **Experimental designs**

Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with one missing observation in case of RBD.

## **UNIT II** **(10 hours)**

### **Incomplete Block Designs**

Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.

## **UNIT III** **(12 hours)**

### **Factorial experiments**

advantages, notations and concepts,  $2^2$ ,  $2^3$ , ...,  $2^n$ ,  $3^2$  factorial experiments, design and analysis, Total and Partial confounding for  $2^n$  ( $n \leq 6$ ), Factorial experiments in a single replicate.

## **UNIT IV** **(10 hours)**

**Fractional factorial experiments:** Construction of one-half and one-quarter fractions of  $2^n$  ( $n \leq 6$ ) factorial experiments, Alias structure, Resolution of a design.

## **PRACTICAL/LAB WORK – (30 hours)**

### **List of Practical:**

1. Analysis of a CRD with equal and unequal replicates.
2. Analysis of RBD.
3. Analysis of LSD.
4. Analysis of RBD with one missing observation.
5. Analysis of  $2^2$  and  $2^3$  factorial in CRD, RBD and LSD.
6. Analysis of  $3^2$  factorial in CRD, RBD.
7. Analysis of a completely confounded two level factorial design in 2 blocks.
8. Analysis of a completely confounded two level factorial design in 4 blocks.
9. Analysis of a partially confounded two level factorial design.
10. Analysis of a single replicate of a  $2^n$  design.
11. Analysis of one half fraction of  $2^n$  factorial design.
12. Analysis of one quarter fraction of  $2^n$  factorial design.

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

## **ESSENTIAL READINGS**

- Das., M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8<sup>th</sup> Edition. World Press, Kolkata.
- Montgomery, D. C. (2008): Design and Analysis of Experiments. John Wiley.
- Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.

## **SUGGESTIVE READINGS:**

- Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
- Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
- Federer, W. T. (1955): Experimental Design, Macmillan, N. Y.
- Anderson, V. L. and McLean, R. A. (1974): Design of Experiments, Marcel Dekker, Inc., N. Y.

- Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer. First Indian Reprint 2006

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### **DISCIPLINE SPECIFIC CORE COURSE –18: ECONOMETRICS**

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

<b>Course title &amp; Code</b>	<b>Credits</b>	<b>Credit distribution of the course</b>			<b>Eligibility criteria</b>	<b>Pre-requisite of the course (if any)</b>
		<b>Lecture</b>	<b>Tutorial</b>	<b>Practical/ Practice</b>		
Econometrics	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions and linear models

#### **Learning Objectives**

A broad knowledge of regression analysis relevant for analyzing economic data.

- Interpretation and critical evaluation of the outcomes of empirical analysis.
- Distinguish the results of violating the assumptions of a classical regression model.
- To judge the validity of the economic theories and carry out their evaluation in numerical terms.
- To extract useful information about important economic policy issues from the available data.
- The course is designed to provide the students with the basic quantitative techniques needed to undertake applied research projects.
- The students learn to quantify and examine economic relationships employing statistical methods based on observed data.

#### **Learning Outcomes:**

After completing this course, students will develop a clear understanding of:

- Students will be trained to write a good quality undergraduate research paper in applied statistics using the econometric methods taught in this class.
- The fundamental concepts of econometrics.
- Specification of the model.
- Multiple Linear Regression.
- Multicollinearity.
- Heteroscedasticity.
- Autocorrelation.
- Autoregressive and Lag models

## **SYLLABUS OF DSC-18**

### **Theory**

#### **UNIT I**

**(15 hours)**

##### **Introduction**

Objective behind building econometric models, Nature and scope of econometrics, model building, role of econometrics. General linear model (GLM). Estimation under linear restrictions.

#### **UNIT II**

**(10 hours)**

##### **Multicollinearity**

Introduction and concepts, detection of multicollinearity, consequences, remedies Multicollinearity, tests and solutions of multicollinearity.

#### **UNIT III**

**(10 hours)**

##### **Generalized least squares and Autocorrelation**

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

#### **UNIT IV**

**(10 hours)**

##### **Heteroscedastic disturbances**

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Qualitative Forecasting Methods.

### **PRACTICAL/LAB WORK – (30 hours)**

#### **List of Practical:**

1. Problems based on estimation of General linear model.
2. Testing of parameters of General linear model.
3. Forecasting of General linear model.
4. Problems related to consequences of Multicollinearity.
5. Diagnostics of Multicollinearity.
6. Problems related to consequences of Autocorrelation (AR(I)).
7. Diagnostics of Autocorrelation.
8. Estimation of General linear model under Autocorrelation.
9. Problems related to consequences Heteroscedasticity.
10. Diagnostics of Heteroscedasticity.
11. Estimation of problems of General linear model under Heteroscedastic disturbance terms.
12. Problems concerning specification errors as a reason for induction of Autocorrelation, Heteroscedasticity and Multicollinearity.
13. Problems related to General linear model under (Aitken Estimation).
14. Forecasting methods.

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

### **ESSENTIAL READINGS**

- Gujarati, D. and Guneshker, S. (2007). Basic Econometrics, 4th Ed., McGraw Hill Companies.
- Johnston, J. (1972). Econometric Methods, 2nd Ed., McGraw Hill International.

**SUGGESTED READINGS:**

- Koutsoyiannis, A. (2004). Theory of Econometrics, 2 Ed., Palgrave Macmillan Limited.
- Maddala, G.S. and Lahiri, K. (2009). Introduction to Econometrics, 4 Ed., John Wiley & Sons.
- Greene, W. H. (2002) Econometric Analysis. 5<sup>th</sup> Edition, Prentice Hall.

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

### **Category II**

#### **DISCIPLINE SPECIFIC ELECTIVE COURSE –: 11 SURVEY SAMPLING**

#### **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		
Survey Sampling	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

#### **Learning Objectives:**

The learning objectives of this course are to introduce:

- Tools and techniques for selecting a representative sample from a target population keeping in mind the objectives to be fulfilled.
- Obtain an estimator of the population parameter on the basis of the selected sample and study its properties.

#### **Learning Outcomes:**

After successful completion of this course, students should be able to:

- Understand the fundamental concepts of population and sample and the principles of sample survey
- Describe the value and methodologies for sample surveys versus other approaches to collecting information from populations.
- Determine the appropriate sample size and its allocation for nationwide sample surveys or for surveys to be conducted in a program area.
- Identify a proper sampling frame and select primary sample points.
- Apply steps involved in selecting a sample using Simple Random Sampling with or without replacement, Stratified Sampling, Systematic Sampling and Ratio and Regression Methods of Estimation