**DEPARTMENT OF STATISTICS**
**FACULTY OF SCIENCE**
**UNIVERSITY OF RAJSHAHI**

## Department of Statistics: At a glance

The Department of Statistics is one of the oldest Departments in the University of Rajshahi, which is the second largest public university of Bangladesh. Since its inception in 1961, the department has evolved steadily. The department offers good teaching and research facilities. At present there are 27 full-time teachers and 21 office staffs. The present enrolments of the students are about 100 and 400 at the graduate and undergraduate programs respectively. The department has its own seminar library with a large number of Textbooks, Journals, and Scientific Literature. A Computer Unit was established in the department in 1990. It is equipped with more than 180 modern personal computers of various models. Both the teachers and students of this department have been using these computers. Occasionally teachers of other departments of the University of Rajshahi are also allowed computer facilities for their research works. Presently the department is offering four courses on computer at the undergraduate and graduate levels. It also offers a certificate course on computer for researchers, professionals and students.

Apart from offering B.Sc. Honours and M.Sc. degrees in Statistics, the department also conducts research for higher studies leading to M. Phil. and Ph. D. degrees. The research works have been concentrated mainly in the areas of Anthropometric Statistics, Bayesian Inference, Biostatistics, Bioinformatics, Biochemical Engineering and Statistical Signal Processing, Bootstrap Techniques, Computer Programming & Simulation, Demography, Earthquake Prediction Modeling, Econometrics, Environmental Statistics, Geo-Statistics, Human Growth, Human Morphology, Industrial Statistics, Linear programming, Order Statistics, Probability, Regression Diagnostics, Reliability Theory, Robust Statistics, Sample re-use Techniques, Social & Educational Statistics, Statistical Data Mining, Statistical Inference, Stochastic Modeling etc.

The department organizes Seminar/Conferences regularly. In the last two decades five international conferences were organized. Occasionally distinguished foreign scholars visit the department and give seminar talks. The department publishes an annual journal named International Journal of Statistical Sciences (IJSS). This is a referred journal and abstracted in the Statistical Theory and Method abstract published by the International Statistical Institute, Netherlands and BANSDOC, Dhaka. For over last 20 years this department has a collaboration program with Indian Statistical Institute, Kolkata. In recent years, the department has launched link programs with Kyoto Gakuen University, Japan and The University of Electro-Communications, Tokyo, Japan.

The department has an association of its own, named “Parishankan Samity”. The aims of this “Samity” are to uphold the academic interests of the department, to organize indoor games, reception party for the new students, farewell party for the outgoing students and bring out a magazine annually. Recently, the alumni of this department have formed Rajshahi University Statistics Alumni (RUSA) in Dhaka to incorporate all ex-statistics students of Rajshahi University from home and abroad to promote academic, research and all other activities of Department of Statistics.

**Name and Research Interest of the Academic Staff**

| SL | Name | Specialization/Field of Interest |
|---|---|---|
| | **Professor** | |
| 1 | Dr. S. K. Bhattacharjee | Bayesian Inference |
| 2 | Dr. Md. Asaduzzaman Shah | Stochastic Modeling, Probability |
| 3 | Dr. Md. Nurul Islam | Demography, Survey Sampling, Applied Statistics, Anthropometric Study, Health Statistics |
| 4 | Dr. M. Sayedur Rahman | Environmental Studies, Statistical Data Mining, Bootstrap, Simulation Modeling |
| 5 | Dr. Anjuman Ara Begum | Demography, Statistical Inference, Order Statistics, Computer Programming |
| 6 | Dr. Md. Ripter Hossain | Demography, Sample Survey, Econometrics, Industrial Management and Health Statistics |
| 7 | Dr. Md. Ayub Ali | Time Series Analysis and Forecasting, Multivariate Analysis, Anthropometric Study, Physical Health and Human Growth, Statistical Modeling, Econometrics, Environmental Statistics, Descriptive Statistics and Applied Statistics |
| 8 | Dr. Md. Golam Hossain | Health Statistics and Physical Anthropology |
| 9 | Dr. Md. Rezaul Karim | Reliability, Bio-Statistics, Computer Programming, Data Science |
| 10 | Dr. Md. Monsur Rahman | Reliability, Bio-Statistics, Statistical Inference |
| 11 | Dr. Dulal Chandra Roy | Sample Survey, Estimation, Operation Research, Quality Control, Applied Statistics |
| 12 | Dr. Md. Nurul Haque Mollah | Robust Statistical Inference, Multivariate Statistics, Optimization, Data Mining, Statistical Signal Processing, Biostatistics, Statistical Genomics and Bioinformatics |
| 13 | Dr. Saroje Kumar Sarkar | Multivariate Analysis, Reliability |
| 14 | Dr. Md. Aminul Hoque | Demography, Bio-informatics, Forecasting, Biochemical Engineering |
| 15 | Dr. Md. Mahmudul Alam (Lien) | Distribution Fitting, Geo-Statistics, Environmental Statistics, Earthquake Prediction Modeling, Computer Programming & Simulation, Data Mining |
| 16 | Dr. Provash Kumar Karmokar | Econometrics, Time Series Analysis and Forecasting, Statistical Modeling of Climatic Variables, Computational Statistics, Simulation and Modeling, Agriculture Statistics |
| 17 | Dr. Md. Jahanur Rahman | Econometrics, Applied Macroeconomics, Financial Statistics and Climate Change |

| SL | Name | Specialization/Field of Interest |
|---|---|---|
| 18 | Dr. Papia Sultana | Semiparametric and Nonparametric Modelling, Medical Diagnostics, Epidemiology |
| 19 | Md. Mesbahul Alam, Ph. D. | Reliability Data Analysis, Warranty, Bio-statistics Optimization, Mathematical Statistics, Robust Statistics, Regression Diagnostics, Computer Programming and Data Mining |
| **Associate Professor** | | |
| 20 | Md. Monimul Huq | Time Series Analysis and Forecasting, Econometrics, Robust Regression and Diagnostics, Multivariate Analysis |
| 21 | Dr. Md. Sabiruzzaman | Time Series Analysis, Econometrics, Robust Statistics, Estimation |
| 22 | Dr. Abu Sayed Md. Al Mamun | Regression Diagnostics and Statistical Modeling |
| 23 | Md. Abdul Khalek | Groundwater Modeling, Environmental Statistics, Computer Programming & Simulation |
| 24 | Dr. Md. Kamruzzaman | Demography and Health Statistics |
| 25 | Farhana Hasan | Demography, Mathematical Economics, Probability Theory, Reliability |
| **Assistant Professor** | | |
| 26 | Md. Hadiul Kabir | Biomedical Statistics and Time Series Analysis |
| 27 | Dr. Md. Mostafizur Rahman | Financial Time Series, Data Mining and Econometrics |

## Vision of the Department:

- To establish the Department of Statistics, University of Rajshahi as a center of excellence for quality education and research;
- To produce skilled and competent human resources to serve the needs of national and international communities;
- To be a leading statistical institute by addressing “better data, better life”.

## Mission of the Department:

- Providing high quality education through adoption of comprehensive programs with a regular updating curriculum for the requirements of contemporary job markets;
- Improving teaching learning environment and infrastructure of the entity to produce competent work force with high level of professionalisms equipped with modern technology and services of dedicated faculties under strategic leadership to contribute to the socio-economic development of the country and make a prosperous nation in the globalized environment.

- Organizing training, research collaboration, workshop, seminar, conference for improving teaching quality and research;
- Promoting scholarly research in statistical theory and application through publications in leading professional journals for the theoretical development of the multidisciplinary field;
- Contributing excellence in research and education in the statistical science through services to the university communities, statistical professions, and societies at large;
- Producing skilled graduates to lead quality research, training and innovation in the field of statistics and multidisciplinary areas to meet the needs of a dynamic world.

## Objectives of this Department:

- Provide professional graduates in the field of statistics and the multidisciplinary areas according to the requirements of contemporary job markets.
- Publish in leading professional journals to contribute the theoretical development and application of statistics addressing substantive problems through scholarly research;
- Disseminate statistical knowledge to ensure effective applications of statistics in real life practices.
- Deliver adequate, relevant and timely statistics to facilitate research, planning and decision making process for the government and the community for achieving Sustainable Development Goals (SDGs) of Bangladesh.

## Curriculum

## B. Sc. Honours in Statistics

## Session: 2017 – 2018

**Part I Examination – 2018**
**Part II Examination – 2019**
**Part III Examination – 2020**
**Part IV Examination – 2021**

### Name of the Program:

B.Sc. Honours in Statistics

### Vision:

This program is to generate skilled and competent graduates as resources equipped with statistics and statistics related modern knowledge that can be meet the needs of the national and global settings.

### Mission:

This program is to produce quality graduates in each and every area of Statistics by providing essential knowledge in Mathematics, Economics, Bioinformatics, Actuarial Science, Physical Health, Environment, Computer Programming and many others.

### Objectives:

- Provide professional graduates in the field of statistics and the multidisciplinary areas according to the requirements of contemporary job markets.
- Disseminate statistical knowledge to ensure effective application of statistics in real life practice.
- Deliver adequate, relevant and timely statistics to facilitate research, planning and decision making program for the government and the community for achieving Sustainable Development Goals (SDGs) of Bangladesh.

### Learning Outcomes:

After the completion of this program graduates will be able to:

- Understand basic principles and more important theories relevant to statistics and their applications;
- Acquire technical knowledge and sound professional practice in the field of statistics and multidisciplinary areas;
- Understand the statistical tools and techniques that are available in Mathematics, Economics, Bioinformatics, Computer Program, and so on;
- Conduct development activities and research project studies using appropriate real life statistical problems;
- Communicate effectively, work as a team and demonstrate high leadership qualities for handling problems on big data.

### Ordinance

The B.Sc. Honours courses in Statistics consist of total 160 credits of 4000 marks (40 units) spread over four academic years. There shall be theoretical, practical and viva-voce examinations at the end of each academic year. The mark, unit and credit distributions are given in Table 1. One unit course carries 4 credits (100 marks) and half unit course carries 2 credits (50 marks). The theoretical examination of one unit

course shall be of 4 hours duration and half unit course shall be of 3 hours duration. Each course contains 80% of the theory marks, 20% in-course marks (15% tutorial/terminal and 5% attendance). Students shall not be allowed to stay for more than three academic years in any of the academic years of the program.

**Award of Degree:** The degree of Bachelor of Science with Honours in Statistics shall be awarded on the basis of CGPA obtained by a candidate in B.Sc. Honours Part-I, Part-II, Part-III and Part-IV examinations. In order to qualify for the B.Sc. Honours degree a candidate must have to obtain within 6 (six) academic years from the date of admission:

*(i) A minimum CGPA of 2.50, (ii) A minimum GPA of 2.00 in the practical courses in each of Part-I, Part-II, Part-III and Part-IV examinations, (iii) 144 credits out of 160 (iv) "S" letter grade in English course in 4 academic years from the date of admission.*

The result shall be given in CGPA with the corresponding LG (Table of LG, GP and CP) in bracket. For instance in the example cited above the result is "CGPA=3.10(B)".

**Publication of Result:** The overall result of a successful candidate covering all examinations of four years shall be declared on the basis of CGPA. The transcript in English shall show the course number, course title, credit, grade and grade point of individual courses, GPA of each year, CGPA and the corresponding LG for the overall result.

**Promotion:** In order to be eligible for promotion from one class to the next higher Honours class and for considering the award of Honours Degree. A candidate must secure (i) at least 2.00 GPA in case of his/her Part-I, Part-II and Part-III examinations, (ii) at least 2.00 GPA in each of his/her Part-I, Part-II and Part-III practical and class assessment/ tutorial/ terminal/home assignment course examinations, and (iii) (a) minimum 30 credits in his/her Part-I examination (b) minimum 30 credits in his/her Part-II examination and 64 credits in total Part-I and Part-II examinations. (c) minimum 34 credits in his/her Part-III examination and 102 credits in total Part-I, Part-II, Part-III examinations. (d) minimum 34 credits in his/her Part-IV examination considering the award of Honours degree.

## Course outline

***Table 1: Marks, Unit and Credit Distributions***

| | Course | Unit | Exam. | Tutorial | CA | Marks | Credit Point |
|---|---|---|---|---|---|---|---|
| **Part-I** | Theoretical | 7.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical[2] | 1.5 | | | | 150 | 06 |
| | Viva-voce and Presentation | 1.0 | | | | 100 | 04 |
| | **Total** | **9.5** | | | | **950** | **38** |
| | English (noncredit)[1] | 0.5 | | | | 50 | 00 |
| **Part-II** | Theoretical | 7.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical[2] | 1.5 | | | | 150 | 06 |
| | Viva-voce and Presentation | 1.0 | | | | 100 | 04 |
| | **Total** | **9.5** | | | | **950** | **38** |

| | Course | Unit | Exam. | Tutorial | CA | Marks | Credit Point |
|---|---|---|---|---|---|---|---|
| **Part-III** | Theoretical | 7.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical[2] | 2.5 | | | | 250 | 10 |
| | Viva-voce and Presentation | 1.0 | | | | 100 | 04 |
| | **Total** | **10.5** | | | | **1050** | **42** |
| **Part-IV** | Theoretical | 9.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical[2] | 2.0 | | | | 200 | 08 |
| | Viva-voce and Presentation | 1.0 | | | | 100 | 04 |
| | Research Project | 0.5 | | | | 50 | 02 |
| | **Total** | **10.5** | | | | **1050** | **42** |
| | **Grand Total** | **40** | | | | **4000** | **160** |

[1.] A candidate shall not be allowed to continue the B.Sc. Honours program if he/she fails to obtain the letter grade "S" in the English course in 4 academic years from the date of admission. The letter grade "S" corresponds to at least 30% marks.

[2.] 30% of the total practical marks shall be allotted for continuous laboratory assessment.

* Exam: Examination, Tut.: Tutorial/Terminal, CA: Class Attendance

**Table 2: Marks on attendance**

| Attendance | Marks |
|---|---|
| 95% - 100% | 5.0 |
| 90% - <95% | 4.5 |
| 85% - <90% | 4.0 |
| 80% - <85% | 3.5 |
| 75% - <80% | 3.0 |

| Attendance | Marks |
|---|---|
| 70% - <75% | 2.5 |
| 65% - <70% | 2.0 |
| 60% - <65% | 1.5 |
| < 60% | 00 |

**Course Improvement:** A promoted student earning a grade point less than **3.00** in individual course(s) shall be allowed to improve the grade(s) on, not more than **two** full unit courses including those of "F" grades, if any, of Part-I, Part-II and Part-III examinations or their equivalent courses (in case of changes in the syllabus), defined by the departmental academic committee, through the regular examination of the immediate following batch. However, if the candidate fails to clear his/her "F" grades in the first attempt, he/she shall get a second (last) chance in the immediate next year to clear the "F" grade(s). No improvement shall be allowed in practical course examinations/ viva-voce/ class assessment/ tutorial/ terminal/ home assignment and thesis/dissertation/project/in-plant training courses. If a candidate fails to improve his/her course grade, the previous grade shall remain valid**.** If a readmitted candidate fails to appear at the regular class assessment/tutorial/terminal/ home assignment and thesis/dissertation/ project/in-plant training courses, his/her previous grades shall remain valid.

**Result Improvement:** A candidate obtaining a CGPA of less than 3.00 at the end of the Part-IV examination, within 5 academic years, shall be allowed to improve his/ her result, on up to a maximum of 4 (four) full courses (16 credits) of the Part-IV

theoretical courses in the immediate next regular examination (within six academic years from the date of admission) after publication of his/her result. The year of examination, in the case of a result improvement, shall remain same as that of the regular examination. His/her pervious grades for practical courses/ viva-voce/class assessment/ tutorial/ terminal/ home assignment, thesis/ dissertation/ project/ in-plant training courses shall remain valid. If a candidate fails to improve CGPA, the previous results shall remain valid.

**Pass Degree:** Candidates failing to obtain required CGPA 2.50 and 144 credits for promotion in Honours part-III examination in 4 (four) academic years, in case of readmission in part-III course year, in 5 (five) academic years, with no readmission in part-III course year from the date of 1st year admission. But fulfill the following conditions. If a candidate fails to obtain required GPA (2.00) and credit point (102) for promotion from Part-III to Part-IV within 5 academic years from his/her first date of admission in first year but secured CGPA 2.00 and total credit point 94 with LG of "S" in the English course, shall be awarded Pass degree. Such candidates shall not be allowed to improve on the Pass degrees.

Or

If a candidate fails to obtain a minimum of 34 credits and GPA (2.00) in his/her Part-IV Examination also fails to obtain 144 credits and CGPA 2.50 within 6 academic years from his/her first date of admission in 1st year but secured minimum CGPA 2.00, 128 credits, with LG of "S" in the English course, shall be awarded Pass degree. Such candidates shall not be allowed to improve their Pass degree

**Dropping Out:** Candidates, failing to earn the yearly required GPA after completing regular examinations and subsequently failed again after taking readmission in 1st, 2nd or 3rd year, or to clear “F” grades in the stipulated period, shall be dropped out of the program.

**Eligibility for Examination:**

a) **Percentage of Attendance:** In order to be eligible for taking up the B. Sc. Honours examinations, a candidate must have pursued a regular course of study by attending not less than 75% of the total number of classes held (theoretical, practical, class assessment etc.) provided that the academic committee of the department on special grounds and on such documentary evidence that may be necessary, may condone the cases of shortage of attendance not below 60%. A candidate, appearing at the examination under the benefit of this provision shall have to pay in addition to the examination fees, the requisite fee prescribed by the syndicate for the purpose. Candidates having less than 60% attendance shall not be allowed to fill up the examination form.

b) **Readmission:** A candidate, who failed to appear at the examination or fails to pass the examination, may on the approval of the relevant department be readmitted to the immediate following session in the first, second, third or fourth year of the program. A readmitted candidate shall have to reappear at all course examinations and complete the program within six academic years.

**The Grading System:**

(a) **Credit Point (CP):** The credit points achieved by an examinee for 0.50 and 1.00 unit course shall be 2 and 4, respectively. For other fractions of a unit, proportionate should be applied.

(b) **Letter Grade (LG) and Grade Point (GP):** Letter Grades, corresponding Grade Points and Credit Points shall be awarded in accordance with provisions shown below:

(i) **Table of LG, GP and CP for credit courses**

| Numerical Grade | LG | GP/unit | CP/unit |
|---|---|---|---|
| 80% or its above | $A^+$ (A plus) | 4.00 | 4 |
| 75% to less than 80% | A (A regular) | 3.75 | 4 |
| 70% to less than 75% | $A^-$ (A minus) | 3.50 | 4 |
| 65% to less than 70% | $B^+$ (B plus) | 3.25 | 4 |
| 60% to less than 65% | B (B regular) | 3.00 | 4 |
| 55% to less than 60% | $B^-$ (B minus) | 2.75 | 4 |
| 50% to less than 55% | $C^+$ (C plus) | 2.50 | 4 |
| 45% to less than 50% | C (C regular) | 2.25 | 4 |
| 40% to less than 45% | D | 2.00 | 4 |
| Less than 40% | F | 0.00 | 0 |
| Incomplete | I | 0.00 | 0 |

Absence from the final examination shall be considered incomplete with the letter grade "I".

(ii) Table of LG, GP and CP for non-credit course (English)

| Numerical Grade | LG | GP/unit | CP/unit |
|---|---|---|---|
| 30% and above | S | 0.0 | 0.0 |
| Less than 30% | U | 0.0 | 0.0 |

Here S and U refer to "satisfactory" and "unsatisfactory", respectively.

**(c) Grade Point Average (GPA) and Total Credit Point (TCP):** The weighted average of the grade points obtained in all the courses by a student and Total Credit Point (TCP) shall be calculated from the following equations:

$$GPA = \frac{\sum_i (CP)_i \times (GP)_i}{\sum_i (CP)_i} \qquad TCP = \sum_i (CP)_i$$

(d) **Cumulative Grade Point Average (CGPA**): The weighted average of the GPAs of a student in all four years shall be calculated from the following equation:

$$CGPA = \frac{\sum_j \{(TCP)_j \times (GPA)_j\}}{\sum_j (TCP)_j}$$

Where, $(GP)_i$ = Grade point obtained in individual courses, $(CP)_i$ = Credit point for respective course, $(GPA)_j$ = Grade point average obtained in a year and $(TCP)_j$ = Total point for that year.

GPA and CGPA shall be rounded off up to 2 (two) places after to decimal to the advantage of the examinee. For instance, GPA = 2.112 shall be rounded off as GPA = 2.12.

The Honours Part-I Examination shall consist of (i) Seven Theory Courses including Tutorial/Terminal and Class Attendance, (ii) Five Practical Sessions including internal evaluation (iii) Viva voce and Presentation. Besides that, there shall be a compulsory course on English (non-credit). The breakdown of marks and credit of Part -I Examination are as follows:

| Exam. | Courses | | Units | Exam. | Tut. | CA | Marks | Credit |
|---|---|---|---|---|---|---|---|---|
| **Part-I, 2018** | Theory | (07) | 7.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical | (01) | 1.5 | | | | 150 | 06 |
| | Viva-voce and Presentation | (01) | 1.0 | | | | 100 | 04 |
| | Total | **(9)** | **9.5** | | | | **950** | **38** |
| | English | (01) | 0.5 | | | | 50 | 00 |

Part-I practical examination shall be of **Twenty hours** in **Five** practical sessions, each of **Four** hours duration.

The Honours Part-II Examination shall consist of (i) Seven Theory Courses including Tutorial/Terminal and Class Attendance, (ii) Five Practical Sessions including internal evaluation (iii) Viva voce and presentation.

The breakdown of marks and credit of Part-II Examination are as follows:

| Exam. | Courses | | Units | Exam. | Tut. | CA | Marks | Credit |
|---|---|---|---|---|---|---|---|---|
| **Part-II, 2019** | Theory | (07) | 7.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical | (01) | 1.5 | | | | 150 | 06 |
| | Viva-voce and Presentation | (01) | 1.0 | | | | 100 | 04 |
| | Total | **(9)** | **9.5** | | | | **950** | **38** |

Part-II practical examination shall be of **Twenty hours** in **Five** practical sessions, each of **Four** hours duration.

The Honours Part-III Examination shall consist of (i) Eight Theory Courses including Tutorial/Terminal and Class Attendance, (ii) Six Practical Sessions including internal evaluation (iii) Viva voce and Presentation. The breakdown of marks and credit of Part-III Examination are as follows:

| Exam. | Courses | | Units | Exam. | Tut. | CA | Marks | Credit |
|---|---|---|---|---|---|---|---|---|
| **Part-III, 2020** | Theory | (08) | 7.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical | (01) | 2.5 | | | | 250 | 10 |
| | Viva-voce and Presentation | (01) | 1.0 | | | | 100 | 04 |
| | Total | **(10)** | **10.5** | | | | **1050** | **42** |

Part-III practical examination shall be of **Thirty hours** in **Six** practical sessions, each of **Five** hours duration.

The Honours Part-IV Examination shall consist of (i) Eight Theory Courses including Tutorial/Terminal and Class Attendance, (ii) Seven Practical Sessions including

internal evaluation (iii) Viva-voce and presentation. The breakdown of marks and credit of Part -IV Examination are as follows:

| Exam. | Courses | | Units | Exam. | Tut. | CA | Marks | Credit |
|---|---|---|---|---|---|---|---|---|
| **Part-IV, 2021** | Theory | (09) | 9.0 | 560 | 105 | 35 | 700 | 28 |
| | Practical | (01) | 2.0 | | | | 200 | 08 |
| | Research Project | (01) | 0.5 | | | | 50 | 02 |
| | Viva-voce and Presentation | (01) | 1.0 | | | | 100 | 04 |
| | Total | **(11)** | **10.5** | | | | **1050** | **42** |

Part-IV practical examination shall be of **Thirty Five hours** in **Seven** practical sessions, each of **Five** hours duration.

For each examination (Part-I, Part-II, Part-III and Part-IV) 30 % of Total Practical Marks shall be allocated for Internal Evaluation. For each Theoretical Course of 75/100 marks, the duration of Examination shall be Four hours and for 50 marks, the duration shall be Three hours.

The Results of a candidate shall be determined on the combined results of Part-I, Part-II, Part-III and Part-IV Examinations.

The Theory courses (by Course numbers and title of Courses) and the Practical Sessions (by Topics of Practical) that shall be offered on yearly basis are given below:

## Detail Course Outline

| **B.Sc. Honours Part-I Examination, 2018** | | | | | | |
|---|---|---|---|---|---|---|
| **Course No.** | **Course Title** | **Full Marks** | | | | **Credit** |
| **Theory** | | **700** | | | | **28** |
| | | Exam | In Course | | Total | |
| | | | Tut. | CA | | |
| B.Stat.-101 | Probability | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-102 | Principles of Statistics I | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-103 | Principles of Statistics II | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-104 | Basic Mathematics and Statistical Indices | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-105 | Calculus | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-106 | Matrix Algebra | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-107 | Introduction to Computer and Numerical Methods | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-108 | English for Statistics | **50** | | | | **00** |

| B.Stat.-109 | Practical | 150 | 6 |
|---|---|---|---|
| Session I | Descriptive Statistics | 30 | |
| Session II | Correlation and Association | 30 | |
| Session III | Regression | 30 | |
| Session IV | Distribution and Curve Fitting | 30 | |
| Session V | Computing Basic Statistics and Numerical Methods | 30 | |

| B.Stat.-110 | Viva-voce and Presentation | 100 | 4 |
|---|---|---|---|
| | **Total** | **950** | **38** |

Exam: Examination, Tut.: Tutorial/Terminal, CA: Class Attendance

**B.Sc. Honours Part-II Examination, 2019**

| Course No. | Course Title | Full Marks | | | | Credit |
|---|---|---|---|---|---|---|
| **Theory** | | 700 | | | | 28 |
| | | Exam | In Course | | Total | |
| | | | Tut. | CA | | |
| B.Stat.-201 | Sampling Distributions and Order Statistics | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-202 | Regression Analysis | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-203 | Analysis of Variance and Experimental Design | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-204 | Economics and Financial Statistics | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-205 | Real Analysis | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-206 | Differential Equations and Linear Algebra | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-207 | Computer Programming | 80 | 15 | 05 | 100 | 4 |

| B.Stat.-208 | Practical | 150 | 6 |
|---|---|---|---|
| Session I | Sampling Distributions and Order Statistics | 30 | |
| Session II | Regression Analysis | 30 | |
| Session III | Analysis of Variance and Experimental Design | 30 | |
| Session IV | Economics and Financial Statistics | 30 | |
| Session V | Computer Programming | 30 | |

| B.Stat.-209 | Viva-voce and Presentation | 100 | 4 |
|---|---|---|---|
| | **Total** | **950** | **38** |

| B.Sc. Honours Part-III Examination, 2020 | | | | | | |
|---|---|---|---|---|---|---|
| **Course No.** | **Course Title** | **Full Marks** | | | | **Credit** |
| **Theory** | | 700 | | | | 28 |
| | | Exam | In Course | | Total | |
| | | | Tut. | CA | | |
| B.Stat.-301 | Multivariate Distributions | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-302 | Estimation | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-303 | Hypothesis Testing | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-304 | Advanced Regression | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-305 | Stochastic Processes | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-306 | Sampling Technique | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-307 | Complex Variable and Transformations | 40 | 7.5 | 2.5 | 50 | 2 |
| B.Stat.-308 | Simulation and Modeling | 40 | 7.5 | 2.5 | 50 | 2 |

| **B.Stat.-309** | **Practical** | **250** | **10** |
|---|---|---|---|
| Session I | Estimation | 45 | |
| Session II | Hypothesis Testing | 45 | |
| Session III | Advanced Regression | 45 | |
| Session IV | Stochastic Processes | 45 | |
| Session V | Sampling Technique | 35 | |
| Session VI | Simulation and Modeling | 35 | |

| B.Stat.-310 | Viva-voce and Presentation | 100 | 4 |
|---|---|---|---|
| | **Total** | **1050** | **42** |

| B.Sc. Honours Part-IV Examination, 2021 | | | | | | |
|---|---|---|---|---|---|---|
| **Course No.** | **Course Title** | **Full Marks** | | | | **Credit** |
| **Theory** | | **700** | | | | **28** |
| | | Exam | In Course | | Total | |
| | | | Tut. | CA | | |
| B.Stat.-401 | Multivariate Analysis | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-402 | Demography | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-403 | Biostatistics and Bioinformatics | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-404 | Economic Statistics and Econometrics | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-405 | Operations Research and Quality Control | 80 | 15 | 05 | 100 | 4 |
| B.Stat.-406 | Probability Measure | 40 | 7.5 | 2.5 | 50 | 2 |
| B.Stat.-407 | Research Methodology | 40 | 7.5 | 2.5 | 50 | 2 |
| B.Stat.-408 | Statistics for Sustainable Development Goals | 40 | 7.5 | 2.5 | 50 | 2 |
| B.Stat.-409 | Actuarial Statistics | 40 | 7.5 | 2.5 | 50 | 2 |

| **B.Stat.-409** | **Practical** | **200** | **08** |
|---|---|---|---|
| Session I | Multivariate Analysis | 30 | |
| Session II | Demography | 30 | |
| Session III | Biostatistics and Bioinformatics | 30 | |
| Session IV | Economic Statistics and Econometrics | 30 | |
| Session V | Actuarial Statistics | 30 | |
| Session VI | Operations Research and Quality Control | 25 | |
| Session VII | Statistics for Sustainable Development Goals | 25 | |
| B.Stat.-410 | Research Project | 50 | 2 |
| B.Stat.-411 | Viva-voce and Presentation | 100 | 4 |
| | **Total** | **1050** | **42** |

## B. Sc. Honours, Part – I, 2018

**B. Stat. - 101**
**Probability**
**Full marks – 100**
**(Examination 80, Tutorial/Terminal 15, and Attendance 5)**
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

### Aim of this Course

This course explores the basic concept of modern probability theory and its applications for decision making in economics, business, other fields of social and natural sciences. This course is heavily oriented towards the formulation of mathematical concepts on basics in sets and probability theory, including probability, conditional probability, random variables, mathematical expectation and variance, probability generating function and special discrete probability distributions with practical applications.

### Objectives of this course

The objectives of this course are to provide students with a formal treatment sets and probability theory. Equipping students with essential tools for statistical analyses at the undergraduate level and fostering understanding through real-world statistical applications. Developing ideas, learn commonly used probability distributions, and be able to conduct basic experimental probability outcomes.

### Learning outcomes of this course

At the end of this course students should be able to develop problem solving techniques needed to accurately calculate probabilities. Students should be able to apply problem-solving techniques to solving real-world events. Students should also be able to use and manipulate the axioms of probability comfortably to derive the results other set operations, use Venn diagrams to represents the results of set operations, understand the concept of random variables in discrete and continuous cases with derive the distribution functions (Joint, marginal and conditional) for both cases. Apply selected probability distribution to solve problem in discrete cares and finally student be able to present the analysis of derive statistics to all relevant and academic audiences.

### Course Content

**Sets:** Sets, type of sets with their operations and applications.

**Combinatories:** Principles of counting, Review of permutations, combinations and series.

**Probability:** Sample space and events, Probability of an event, Frequency limit and probability, Axioms of probability, Addition law of probability, Guessing and classical occupancy problems, Applications of Bose-Einstein statistics, Conditional probability, Multiplication law of probability, Partitions, Bayes' theorem with applications, Independent events, Dependent and independent trials, Other aspects of probability.

**Random Variables:** Basic concepts, Discrete and continuous random variables, Density and distribution functions, Mathematical expectation and variance, Joint distributions, Independent variable, Marginal and conditional distributions,

Conditional expectation and variance, Moment generating functions, Cumulant generating functions, Characteristic function, Functions of a random variable, Markov and Chebyshev inequalities, Law of large number, Central limit theorem.

**Discrete Distributions:** Bernoulli, Binomial, Multinomial, Negative Binomial, Poisson, Geometric and Hyper Geometric distributions.

**Main Books Recommended:**


Lipschutz, S. and J. Schiller (2011). *Introduction to Probability and Statistics*, McGraw-Hill, N.Y.

Ross, S. M. (2014). *Introduction to probability models*. Academic press.


**References:**


Chung, K. L. (2006). *Elementary Probability Theory with Stochastic Process*, 4th ed., Springer - Verlag, N.Y.

Feller, W. (2008). *An introduction to probability theory and its applications* (Vol. 2). John Wiley & Sons.

Marx, M. L., & Larsen, R. J. (2006). *Introduction to mathematical statistics and its applications*. Pearson/Prentice Hall.

Schinazi, R. B. (2011). *Probability with statistical applications*. Springer.


## B. Stat. - 102
## Principles of Statistics I
## Full marks – 100
## (Examination 80, Tutorial/Terminal 15, and Attendance 5)
## Number of Lecturers - Minimum 60
## *(Duration of Examination: 4 Hours)*

**Aim of the Course**

This is a very basic and introductory course of statistics. Stress has been laid on concepts, data processing, exploratory data analysis, statistical tools and techniques of analyzing data. Well known continuous probability distribution are also provided in this course.

**Objective of the Course**

After completing this course, the student will understand

- data, nature of data, how to process and condense the data
- apply appropriate statistical tools and techniques to analyze the data
- well known continuous probability distribution and their properties
-

**Learning Outcomes**

At the end of the course, one can understand

- how to organize and condense the data to gather knowledge regarding data
- how to present a systemic account of the statistical procedures which have very wide applications in various field

- to know the applications of statistical ideas , tools and techniques in real life problem
- how to interpret the data
- to know well known continuous probability distribution and their applications in various field
- the students and research workers will acquire from this course a sound understanding of this basic statistical tools and techniques.

## Course Content

**Introduction to Statistics:** Origin, history, meaning, classification and scope, limitations, uses and abuses of statistics. Basic concepts: population, sample, parameter, statistic, variable and attribute.

**Data Processing:** Meaning, types of data, organization and presentation of data: classification and tabulation, frequency distribution, graphical representation of qualitative and quantitative data.

**Exploratory Data Analysis (EDA):** Central tendency, dispersion, moments, skewness and kurtosis with their properties and applications.

**Continuous Distribution:** Normal, Uniform, Exponential, Logarithmic, Beta, Gamma, Cauchy, Laplace and Weibull, Pearson's system of curves.

**Main Books Recommended:**


Cramér, H. (2011). *Mathematical methods of statistics*. Princeton university press.

Marx, M. L., & R. J. Larsen (2006). *Introduction to mathematical statistics and its applications*. Pearson/Prentice Hall.

Weiss, N. A., & C. A. Weiss (2012). *Introductory statistics*. Pearson Education.


**References:**


Bartoszynski, R., & M. Niewiadomska-Bugaj (2007). *Probability and statistical inference*. John Wiley & Sons.

Behrens, J. T., & Yu, C. H. (2003). *Exploratory data analysis*. Handbook of psychology.

Bulmer, M. G. (2012). *Principles of statistics*. Courier Dover Publications.

Casella, G., & R. L. Berger (2002). *Statistical inference* (Vol. 2). Pacific Grove, CA: Duxbury.

Cox, D. R., & C. A. Donnelly (2011). *Principles of applied statistics*. Cambridge University Press.

Kardaun, O. J. (2005). *Classical Methods of Statistics*. Springer-Verlag Berlin Heidelberg.

Longnecker, M., & R. Ott (2001). *An introduction to statistical methods and data analysis*. ISBN-13, 854576151.

Triola, M. F., Goodman, W. M. LaBute, G., Law, R., & L. MacKay (2006). *Elementary statistics*. Pearson/Addison-Wesley.

**B. Stat.- 103**
**Principles of Statistics II**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of the course**

The aim of this course is to provide you with an opportunity to expand their knowledge and skills of the Statistical Concepts and a personal development experience towards the needs of bivariate statistical data.

**Objective of the course**

After completing this course, the student should

- understand the feathers of various correlations
- apply appropriate correlation according to the nature of the data
- understand the feathers of simple regression
-

**Learning Outcomes**

At the end of the course, the student will be able to

- understand method and concept of simple and multiple correlations, rank correlations.
- evaluate and interpret the outcomes of correlation coefficients
- develop an understanding of the theoretical basis for linear regression analysis
- be able to understand about bivariate probability distribution and its properties.

**Course Content**

**Correlation and Regression:** Bivariate data, scatter diagram, Bivariate table, Conditional means and variances, Marginal distributions, Simple Correlation, Correlation ratio, Rank correlation, Spearman rank correlation, Partial and multiple correlation, Spurious correlation and Non-sense correlation, Two variable linear regression, Estimation of parameters with properties, Residual analysis, Three variables regression (without matrix approach).

**Analysis of Attributes:** Basic ideas, classification, Order of classes and class frequencies, Ultimate class frequencies, Positive attributes, Consistency, Incomplete data, Association of attributes, Independence, Complete association and disassociation, Measures of association, Coefficient of association and colligation, Partial association, Analysis of 2 x 2 and r x c contingency table, Yate's correction.

**Bivariate Distributions:** Concept of bivariate probability distribution, Marginal and conditional distributions, Expected values and variances, Moments and cumulants. Moment and cumulant generating functions, Derivation of bivariate normal distribution and study of its properties, Normal regression.

**Main Books Recommended:**

Bartoszynski, R., & M. Niewiadomska-Bugaj (2007). *Probability and statistical inference*. John Wiley & Sons.

Johnston, J. (1997). *Econometric Methods*, 4th ed., McGraw-Hill, N.Y.

Yule, G. U. and M. G. Kendall (1994). *An Introduction to the Theory of Statistics*, 14th ed., Charles Griffin, London.

**References:**

Bulmer, M. G. (2012). *Principles of statistics*. Courier Dover Publications.

Casella, G., & R. L. Berger (2002). *Statistical inference*. Pacific Grove, CA: Duxbury.

Cox, D. R., & C. A. Donnelly (2011). *Principles of applied statistics*. Cambridge University Press.

Feller, W. (2008). *An introduction to probability theory and its applications*. John Wiley & Sons.

Kendall, M.G. and A. Stuart, (2004). *Advanced Theory of Statistics*, 14th ed., Edward Arnold, N.Y.

Sanders, D. H., & R. K. Smidt (2000). *Statistics: A first course*.

Silverman, D. (2011). *Interpreting qualitative data*. Sage.

## B. Stat.- 104
## Basic Mathematics and Statistical Indices
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lectures - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of this course**

This course is designed to introduce the basic concept of algebra, geometry, time series component and statistical indices due to the level of students. It is widely recognized that a student's ability to use mathematics is a key element in determining subsequent success.

**Objectives of this course**

- Conceptualize the basic idea of set theory.
- Understand the basic concept of geometry.
- Familiar with the basic concept of theory of equations.
- Acquire knowledge on time series.
- Obtain information on statistical indices.

**Learning outcome of this course**

At the end of the course the students be able to

- Solve compound inequalities in the form of "or" and express the solution graphically.
- Solve compound inequalities in the form of "and" and express the solution graphically.
- Realize the concept of different type algebraic with simple examples.
- Categorize the component of time series.
- Gain knowledge about meaning and application of statistical indices.

## Course Content

**Basic Concepts of Algebra:** Binary relation, operation, equivalence relation, properties of real number and complex number, and definition of group and field.

**Theory of Equations:** Theory of equations, Polynomial and polynomial equations, The remainder theorem in algebra, Multiple roots, Relation between roots and coefficients, Des Carte's rule of signs, Symmetric function of the roots, Solutions of cubic and bi-quadratic equations.

**Inequalities:** Introduction to inequalities, Simple inequalities, Inequalities involving a modulus, Inequalities involving quotients, Inequalities involving square functions, Quadratic inequalities.

**Time Series:** Basic concepts, different components with their measurement and uses.

**Index Numbers:** Meaning of index numbers, problems in the construction of index numbers, classification and calculation of index numbers, mathematical test of index numbers, cost of living index number.

**Health Indices:** Basic concept of physical quality of the life index (PQLI), Human Development Index (HDI), Body Mass Index (BMI), Cephalic Index (CI), Cranial Index (CI), Ponderal Index (PI), Glycaemic Index (GI), Morphological index (MI), Bacterial index (BI), Demographic indices (DI), Healthy Eating Index (HEI) and Healthy Life Expectancy Index (HLEI).

**Economic and Social Index:** Basic concept of Consumer price Index (CPI), Wage Rate Index (WRI), Corruption Perception Index (CPI), World Development Index (WDI), Poverty Index (PI), Environment Vulnerability Index (EVI), Environment Performance Index (EPI) and Environment Sustainability Index (ESI).

**Main Books Recommended:**


Ayres, F. (1965): Theory and Problems of Modern Algebra, Schaum's Outline Series, McGraw-Hill Book Company.

Anton, H. (2000): Calculus with Analytic Geometry, Wiley, N.Y.

Fuller, G. (1977): College Algebra, D. Van Nostrand Company, New York, USA.

Horn, V. Robert (1993): Statistical Indicators for the Economic and Social Sciences, Cambridge University Press.

WHO (2014): Global Reference List of Core Health Indicators: Working Version 5


**Reference:**


Bangladesh Bureau of Statistics (2016): Monthly Release on Consumer price Index, Inflation Rate and Wage Index in Bangladesh, Bangladesh Bureau of Statistics, Ministry of Planning.

Hildeerbrand (1984): Introduction to Numerical Analysis.

Littlewood, D. E. (1977): University Algebra, Oxford University Press, Oxford

Van Der Waerden,BL (1966): Modern Algebra, Frederick Ungar publishing Co., New York.

**B. Stat.- 105**
**Calculus**
**Full marks – 100**
**(Examination 80, Tutorial/Terminal 15, and Attendance 5)**
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of the Course**

The aim of this course is twofold: to study the general knowledge of real number theory, differential and integration of the function of one variable, the theory and means of the definite integrals and indefinite integrals and so on.

**Objectives of** the Course

After completing this course, the students should

- know and demonstrate understanding of the concepts from the five branches of mathematics (number, algebra, geometry and trigonometry, statistics and probability, and discrete mathematics)
- use appropriate mathematical concepts and skills to solve problems in both familiar and unfamiliar situations including those in real-life contexts
- select and apply general rules correctly to solve problems including those in real-life contexts.

**Learning Outcomes**

At the end of the course, students should be able to:

- recognize properties of functions and their inverses;
- sketch graphs, using function, its first derivative, and the second derivative;
- apply the procedures of differentiation accurately, including implicit and logarithmic differentiation;
- perform accurately definite and indefinite integration, using parts, substitution, inverse substitution; and
- understand and apply the procedures for integrating rational functions.

## Course Content

**Numbers:** Introduction to number, Natural, Rational, Irrational, Real, Real line, Complex, Absolute value of real number, Properties of absolute values.

**Functions**: Function and relation, Domain, Range, Inverse Function and Graph of functions like exponential, logarithmic, sine, tangent etc., limits, continuity, and indeterminate form, L' Hospitals rule.

**Ordinary Differentiation**: Introduction to differentiation, Successive differentiation and Leibnitz theorem, Maxima and minima.

**Expansions of Functions:** Introduction and application: Rolle's Theorem, Mean Value Theorem, Taylor's and Maclaurin's Formulae.

**Partial Differentiation**: Functions of several variables, continuity of a function of two variables, Limit of a function of two variables, partial derivatives and its geometrical representation, Total differential, Total differential co-efficient, Partial differentiation of implicit functions, Perfect or exact differential, homogeneous functions, Euler's theorem, Converse of Euler’s theorem, Maxima and minima, Tangents and Normal, Asymptotes, Jacobians and its properties, Taylor's theorem for several variables.

**Indefinite Integrals**: Method of substitution, Integration by parts, Integration by reduction, Special trigonometric functions, Rational fractions.

**Definite Integrals:** Fundamental theorem, General Properties, Evaluations of definite integrals and reduction formulae, Ideas of double integral, Triple integral, Rectification, Areas of plane curves, Volumes and solids of revolution.

**Main Books Recommended:**

Anton, H (2000): Calculus with Analytic Geometry, Wiley, N.Y.
Stewart, J. (2003): Calculus: Early Transcendentals (5th Ed.) Brooks/Cole, N.Y.

**References:**

Ayres, F. (1982): Calculus, McGraw-Hill, N. Y.
Binmore, K.G. (1983): Calculus, CUP, London.
Buck, R. C. (1977): Advanced Calculus, 3rd ed. McGraw – Hill, N.Y.
Edwards, J, (1994): Differential Calculus, Macmillan, London
Lang, S. (1988): First Course in Calculus, 5th ed., Springer-Verlag, N.Y.
Maxwell, A.E. (1957): An Analytical Calculus, Part I & II, C.U.P., London

## B. Stat.- 106
## Matrix Algebra
## Full marks – 100
## (Examination 80, Tutorial/Terminal 15, and Attendance 5)
## Number of Lectures - Minimum 60
## *(Duration of Examination: 4 Hours)*

**The Aim of the course**

The aim of this course is to provide an overview of the relevant aspects with basic algebraic properties of matrices and to accustomed with the fundamentals of vectors.

**Objectives of the Course**

After completing this course, students should

- understand the concept of matrix and vectors
- prepare for basic matrix operation
- able to solve the practical problems
- able to apply matrix algebra in statistics as well as in any other field.

**Learning outcomes**

At the end of the course students will be able to

- know the fundamental the concepts.
- develop specific skills and competencies covered in this course.
- apply course material to solve problems.
- use of linear algebra in any other branches.

## Course Content

**Vectors:** Plane and real line as geometric and algebraic vector spaces, their relations, Linear dependence and independence, Vector space, Basis, Dimension, Sub-space, Dot product, Direct sum, Kronecker product, Projection, Gram-Schmidth orthogonalization, Cauchy-Schewartz inequality.

**Matrices:** Basic operations, Types of matrices, Trace, Determinants, Rank, Inverse with their properties and applications, Inverse by partitioning, Block matrices and their multiplication, Solution of system of linear equations, Characteristic equations, Latent root and vector, Generalized inverse, Moore-Penrose inverse, Quadratic forms and its geometric interpretations. Diagonalization, Spectral decomposition, LU and QR decompositions and its importance.

**Main Books Recommended:**


Basilevsky, A. (2013). *Applied matrix algebra in the statistical sciences*. Courier Dover Publications.

Eldén, L. (2009). *Matrix Methods in Data Mining and Pattern Recognition*. AMC, 10, 12.


**References:**


Frank Jr, A. Y. R. E. S. (1996). *Matrices*. Colección Schaum. McGraw Hill.

Harville, D. A. (2008). *Matrix algebra from a statistician's perspective*. Springer.

Lipschutz, S., & M. Lipson (2001). *Schaum's outline of theory and problems of linear algebra*. Erlangga.

Rao, C. R. (2009). *Linear statistical inference and its applications* (Vol. 22). John Wiley & Sons.

Searle, S. R. (1982). *Matrix algebra useful for statistics*. New York.

Seber, G. A. (2008). *A matrix handbook for statisticians*. John Wiley & Sons.

Strang, G. (2003). *Introduction to linear algebra*. Cambridge Publication.


## B-Stat.- 107
## Introduction to Computer and Numerical Methods
**Full marks – 100**
**(Examination 80, Tutorial/Terminal 15, and Attendance 5)**
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of this course**

This course is designed to enhance fundamental concept of computer learning and its application in statistics. Also, improve student's expertise in numerical methods.

**Objective of this course**

- improve the student's skills in numerical methods by using the numerical analysis with the help of statistical software.
- further develop and apply problem solving skills in numerical methods by giving emphasize on non-linear equations, interpolation, differentiation, and integration.

**Learning Outcomes**

- Know how to implement numerical methods on the specific problem
- Know the flexible use of numerical methods in application to real problems.
- Using Statistical software to implement numerical methods.

**Course Content**

**Computer Fundamentals:** Introduction, History, Characteristics, Types and application of computer, Hardware, Software, Classification of software. Utility programs and computer virus, Computer language, Compiler and interpreter, Network, Classification of network, Internet and Operating systems, Advantage and disadvantages of operating system, Statistical software Packages.

**Computer Numbering Systems:** Binary, Octal, Decimal, and Hexadecimal, with their relationships.

**Numerical Methods**: Accuracy of approximate calculation interpolation and extrapolation, Differences of a polynomial, Finite difference operator, Difference table, Difference equations, Interpolation- Newton's forward, Backward, Central difference, Gauss', Stirling's and Bessel's formulas, Inverse interpolation, Accuracy of interpolation, Numerical differentiation and integration, Accuracy of quadrature, Numerical solution of equations, Convergence of these methods and their inherent errors, Numerical solution of simultaneous linear equations.

**Main Books Recommended:**

Rajaraman, V. (2010). *Fundamentals of computers*. PHI Learning Pvt. Ltd..

Stoer, J., & R. Bulirsch (2002). *Introduction to numerical analysis* (Vol. 12). Springer.

Scarborough, J. B. (1966). *Numerical Mathematical Analysis*, 6th ed., Johns Hopkins Press, Baltimore.

**References:**

Heck, A. (2003). *Introduction to maple*. Springer-Verlag New York, Inc..

Littlewood, D. E. (2005). *University Algebra*, Oxford University Press, Oxford.

Norton, P. (2006). *Introduction to Computers*, 6th ed., McGraw-Hill Book Company, N.Y.

Ulam, S. M. (2004). *Problems in modern mathematics*. Courier Dover Publications.

## B. Stat.- 108
## English for Statistics
## (Non-Credit)
## Full marks – 50
## Number of Lectures - Minimum 30
## *(Duration of Examination: 3 Hours)*

**Aim of this Course**

The aims of this course are to gather more knowledge regarding grammatical concepts, reading, writing and communication skills that are frequently used in the

field of statistics. It also helps to create an open friendly classroom environment, to create something new ideas based on the acquired knowledge of skills; understand and apply the conventions of academic writing in English. Students can identify the pros and cons of the grammatical point of view and will be use the parts of speech analyze, which is measurable.

**Objectives of this Course**

This course will develop the students' ability to

- interact with academic content: reading, writing, listening, speaking;
- demonstrate ability to think critically;
- utilize information and digital literacy skills;
- demonstrate behavior and attitudes appropriate to a university environment;
- make inferences and predictions based on comprehension of a text.

**Learning Outcomes of this course**

On successfully completion of this course, the student will be able to:

- identify the main idea(s) in the text;
- infer meanings of unfamiliar words;
- produce academic vocabulary appropriately orally and in writing; and
- summarize/paraphrase information in a text.
- focus the topic and apply research procedures;
- produce appropriate vocabulary;
- produce accurate grammatical forms; and
- give an oral presentation in class using effective delivery strategies.

**Course Content**

**Functional English:** Review of part of speech; Articles; Phrases and clauses; Basic sentence structures, Verb-tense and its forms (Conjugation); Punctuations; Structure of simple, compound and complex sentences; Narrations; Voice-change of voice; Corrections.

Comprehensions; Different types of paragraph writing; Report writing on a small projects; Academic writing.

**Main Books Recommended:**

Ahmed Sadruddin. Learning English, the easy way. Bangla Academy Tathya Ganit, Dhaka.

Swan, M. (2005). *Practical English usage* (Vol. 95). Oxford: Oxford University Press.

**References:**

Carter, S.Mc. and S. Ash (2003). *IELTS Test builder*, Macmillan.

Dodge, Y., Cox, D., D. Commenges, P. J. Solomon, & S. Wilson (2003). *The Oxford dictionary of statistical terms*. Oxford University Press.

**B. Stat.- 109**
**Practical**
**Full Marks-150**
(70% for Practical Exam. and 30% for continuous Lab assessment)
**(Five sessions, each of Four hours durations)**

**Session I: Descriptive Statistics (Related to B. Stat.- 102) (Marks 30)**

1. Collection of simple data of size 100 on at least two continuous and two quality variables by individual student.
2. Preparation of frequency distribution table and graphical representation.
3. Computation and interpretation of various measures of central tendency and dispersion from ungrouped (raw) and grouped data.
4. Calculation of moments and the measures of skewness and kurtosis from ungrouped and grouped data and their interpretation.
5. Stem-and-leaf displays and box plots of data.

**Session II: Correlation and Association (Related to B. Stat.- 103) (Marks 30)**

1. Collection of simple data of size 100 on at least two continuous and two quality variables by individual student.
2. Preparation of scatter diagram showing all types of relationship between two variables.
3. Computation of all types of Correlation coefficients indicated in B-Stat 102.
4. Association, Independency, Consistency and Contingency analysis of attributes

**Session III: Regression** (**Related to B. Stat.- 103**) **(Marks 30)**

1. Obtaining normal equations from a system of linear equations and their most plausible solutions.
2. Fitting of two and three variables regression models by the method of Least squares when the models are linear in parameters and linear in variables.
3. Computation of partial and multiple correlation and regression coefficients and their interpretation – Three variables case.
4. Residual analysis.

**Session IV: Distribution and Curve Fitting (Related to B. Stat.- 101, 102) (Marks 30)**

1. Detection of types of curve by graphical procedure.
2. Fitting of linear, reciprocal, logarithm, inverse-logarithm, semi-logarithm, double logarithm, Exponential, logistic, Gompertz and Makeham types of curves.
3. Coin tossing experiments by the students and graph of relative frequency of heads, graphical display of CLT.
4. Fitting of probability distribution**–**Binomial, Poisson, Negative Binomial, Normal, Geometric and Rectangular.
5. Calculation of index numbers using various formulas
6. Fitting of trend lines using time series data.

**Session V**: **Computing Basic Statistics and Numerical Methods** (**Related to B. Stat.- 102, 103,104, 105,106 & 107**) **(Marks 30)**

Make solution of the problems using Excel

1. Graphical representation of statistical data. Preparation of scatter diagram showing different types of relationship between two variables.
2. Computation of various measures of central tendency: AM, GM, HM. Dispersion: range, standard deviation, mean deviation from mean. Moments, skewness and kurtosis from ungrouped data.
3. Shorting of a data set.
4. Analysis of correlation and regression.

**Make solution of the problems using Maple:**

1. Summation/Product of different Series.
2. Matrix operation: Transpose, Addition, Subtraction and Multiplication.
3. Solution of simultaneous equations.
4. Numerical Differentiation.
5. Numerical Integration.

**B. Stat.- 110**
**Viva-voce and Presentation**
**Full Marks-100**

**B. Stat.-201**
**Sampling Distributions and Order Statistics**
**Full marks – 100**
Examination 80, Tutorial/Terminal 15, and Attendance 5
**Number of Lectures – Minimum 60**
*(Duration of examination: 4 Hours)*

**Aim of this course**

This course is designed to afford basic concept and the application of transformation, sampling distribution and order statistics.

**Objective of this course**

- Transfer one variable to another variable by different method of transformation.
- Depict the role of sampling distributions in inferential statistics.
- Demonstrate general strategies for problems about order statistics
- Explore the application area of order statistics in real life as well as statistical theory.

**Learning outcome of this course**

At the end of the course the students will be able to

- apply different methods of transformation in various distributions.
- estimate the sampling distribution of mean, variance, correlation and regression coefficients.
- the shape of sampling distribution to interpret the nature of statistical data.
- establish the interrelationship in t, F and chi-square distribution.
- derive the distribution function of the smallest, largest and $r^{th}$ order statistic
- construct confidence interval for quantities and distribution free tolerance interval.

## Course Content

**Transformation of Variables:** Introduction, Distribution of function of random variable(s), Probability integral transformation, Transformation of variables-using Jacobian, Distribution function and moment generating function techniques, Problem on transformation of variables related to Binomial, Poisson, Uniform, Normal, Exponential, Gamma, Beta, Weibull and Extreme value distributions, Delta methods for finding mean and variance of function of random variable(s).

**Sampling Distributions**: Introduction, Meaning of parent and sampling distributions, Methods of deriving sampling distribution, Fisher's lemma, $\chi^2$, t and F distributions with their properties and applications, Distribution of sample mean, variance, skewness, kurtosis, proportion and difference between two sample proportions, Distribution of Regression and correlation coefficients for null case.

**Distribution of Order Statistics:** Introduction, Joint and marginal distributions of order statistics, Distribution of functions of order statistics, Illustrations from different parent distributions, Expected values and moments of order statistics, Applications.

**Main Books Recommended:**

Hogg, R. and A.T. Craig (2002): *Introduction to Mathematical Statistics*, 5th ed., Pearson Education Asia.

Marx, M. L., & R. J. Larsen (2006). *Introduction to mathematical statistics and its applications*. Pearson/Prentice Hall.

**References:**

Bartoszynski, R., & M. Niewiadomska-Bugaj (2007). *Probability and statistical inference*. John Wiley & Sons.

Brunk, H. D., & T. Teichmann (2009). *An introduction to mathematical statistics*. Physics Today, 13(11), 50-52.

David, H.A. (1980): *Order Statistics*, 2nd ed., Wiley, N.Y.

Forbes, C., M. Evans, N. Hastings, & B. Peacock (2011). *Statistical distributions*. John Wiley & Sons.

Johnson, N. L., A. W. Kemp, & S. Kotz (2005). *Univariate discrete distributions*. John Wiley & Sons.

Kendall, M.G. and A. Stuart (2004): *Advanced Theory of Statistics*, 14th ed., Edward Arnold, N.Y.

Kotz, S., N. Balakrishnan and N. L. Johnson (2000): *Continuous Multivariate Distributions*, Vol. 1, Models and Applications, 2nd ed., Wiley, N.Y.

Mood, A.M., F. A. Graybill and D.C. Boes (2013). *Introduction to the theory of Statistics.* 11th ed., McGraw–Hill, N.Y.

## B. Stat.- 202
## Regression Analysis
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lectures - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aims of this Course**

The aim of this course is twofold: to provide you with an overview of the most common techniques used to quantify regression analysis, and to enlighten how to establish relationship and model building techniques.

**Objectives of this Course**

After completing this course, the students should

- understand all the features of regression analysis;
- apply and fit appropriate regression model according to the nature of data;
- critically analyzing results obtained from fitting regression model;
- develop the capability of model building strategies;

**Learning outcomes of this course**

At the end of the course, the students will be able to

- know when it is appropriate to use a regression model;
- know what a regression analysis allows you to do;
- know what is the appropriate techniques of formulating, analyzing and forecasting of bivariate/multivariate data;
- know the interpretation the result of the model fitting

## Course Content

**Multiple Linear Regression:** Estimation of parameters with their properties and Residual analysis for multiple and restricted linear regression through OLS, GLS and WLS methods. Inverse regression.

**Estimation Problems in Linear Regression Model:** Identification, test and possible solutions for the problems of Mutlicollinearity, Heteroscedasticity, Autocorrelation, Errors in Variables and Errors in Equations.

**Model Building and Adequacy:** Variable selection and model building through stepwise regression procedure, Cp criterion, Akaike information criteria, Schwartz criteria, detection of outlier, influential observations, and high leverage points. Test for significance of the model and model parameters, contribution, Lack of fit and pure error. Model adequacy.

**Dummy Variable Regression:** Introduction, uses and applications in regression analysis as independent variable(s). Dummy variable trap. Uses and applications in regression analysis as dependent variable such as: linear probability, logit, probit and tobit models. Logistic regression with its uses, interpretations and test for goodness of fit.

**Main Books Recommended:**

Draper, N. R. and H. Smith (2003). *Applied Linear Regression*, 3rd ed., Wiley, N.Y.

Montgomery, D. C., E. A. Peck, & G. G. Vining (2012). *Introduction to linear regression analysis* (Vol. 821). John Wiley & Sons.

Weisberg, S. (2014). *Applied linear regression*. John Wiley & Sons.

**References:**

Birkes, D., & Y. Dodge (2011). *Alternative methods of regression* (Vol. 190). John Wiley & Sons.

Crawford, S. L. (2006). *Correlation and regression*. *Circulation*, *114*(19), 2083-2088.

Dobson, A. J. (2001). *An introduction to generalized linear models*. CRC press.

Washington, S. P., M. G. Karlaftis & F. L. Mannering (2010). *Statistical and econometric methods for transportation data analysis*. CRC press.

**B. Stat.- 203**
**Analysis of Variance and Experimental Design**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of the Course**

The main aim of this course is to analyze the differences among group means and their associated procedures (such as "variation" among and between groups), developed by Ronald Fisher. Comparisons of mean squares, along with an F-test allow testing of a nested sequence of models.

**Objective of the Course**

After completing this Course, student should

- Learn how to analyze the total variation to its component variation;
- Notice the pairwise difference whether it is significant or not.
- Understand comparative design are Important to choose between alternatives with narrow scope, suitable for initial comparison

**Learning Outcomes**

At the end of the course, the students will be able to

- know when it is appropriate to use ANOVA;
- know when it is appropriate to use ANCOVA;
- know where and how an appropriate design should be applied.

**Course Content**

**Analysis of Variance:** Definition, Assumptions, Analysis of variance (ANOVA) corresponding to one-way, two-way and three-way classifications, fixed, random and mixed effect models, Parametric function and contrasts, Variance components analysis.

**Analysis of Covariance**: Introduction, Concomitant variable, Analysis of covariance in one-way, two-way and three-way classifications with one concomitant variable.

**Experimental Design:** Basic concept, Principles of experimental design, Requirements of a good experiment.

**Orthogonal Design:** Completely randomized design, Randomized block design, Analysis including interaction effects, Latin square design, Efficiency of a design, Missing plot technique in RBD and LSD.

**Factorial Experiment:** Basic ideas, description and analysis of $2^p$, $3^p$, p×q factorial experiments, Confounding, Split plot design.

**Main Books Recommended:**

Montgomery D. C. (2011). *Design and Analysis of Experiments*, 9th ed., Wiley.
Cohran and Cox (2000): Experimental Design, 2nd ed., John Wiley, N.Y.
Federer, W.T. 1955. Experimental design, Mcmillan, New York.
Fisher, R.A.(1995): Design of Experiment, 8th ed., Hafner, N.Y.

**References:**

Brown, S. R., & L. E. Melamed (1990). *Experimental design and analysis*. Sage.

Gerber, A. S., & D. P. Green (2012). *Field experiments: Design, analysis, and interpretation*. New York: WW Norton.

Kleijnen, J. P. (2008). *Design of experiments: overview*. In Simulation Conference, 2008. WSC 2008. Winter. IEEE.

Wang, W. Z., S. S., Mao & L. R. Zeng (2004). *Design and analysis of experiments*. lecture notes. Department of Industrial and Information Management, National Cheng Kung University Tainan, Taiwan, ROC, http://ioml. iim. ncku. edu. tw/textbooks.

## B. Stat. - 204
## Economics and Financial Statistics
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lectures - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of the Course**

The aim of this course is to provide an introduction to basic statistics and mathematics within economical and financial context.

**Objectives of the Course**

After completing this course, the students should

- judge the appropriate statistical methods for analyzing and interpreting economic and business data;
- focus on data science as an analytical and decision making tool, in a variety of business contexts, with a major emphasis on interpretation and application.

**Learning Outcomes of the Course**

At the end of the course, the students will be able to

- summarize and interpret economical and financial information;
- apply fundamental concepts of probability and probability distributions to problems in business decision-making.

**Course Content**

**Introduction:** Basic concept, Demand, Supply and market equilibrium, Types and determinant of elasticity, Law of diminishing marginal utility, Economic circular flow, Household consumption, Inflation and consumer price index, Concept of globalization and free trade.

**Functions of Insurance:** Definition, Nature and functions of insurance, Types of insurance, Economic theories of insurance, Mathematical basis for insurance, Benefits and costs of insurance system to the society, Loss, Hazard and risk, Types of risks.

**Banking System of Bangladesh:** Basic concepts and terminologies, Financial system, Money and supply, Roll of central bank, Credit control tools, Money laundering-definition, reasons, process and penalties, Banking functions.

**Financial Institutions and Markets:** Role, Function and types of financial markets, Financial assets and financial transactions, Characteristics of financial assets, Financial instruments, Interest rate, Exchange rate, Risk and return in finance, Measures of risk, Nature of market risk, Systematic and non-systematic risk, Portfolio risk management, Mean-variance portfolio model.

**Main Books Recommended:**

Cvitanic´, J. and F. Zapatero (2004). Intr*oduction to the Economics and Mathematics of Financial Markets*. MIT Press.

Rejda, G. E. (2011). *Principles of risk management and insurance*. Pearson Education India.

**References:**

Bowers, N. L., H. U. Gerber, J. C. Hickman, D. A. Jones, and C. J. Nesbitt (1997). Actuarial Mathematics. Society of Actuaries.

Mankiw, N. G. (2011). *Principles of Economics*. 6th ed. Cengage Learning.

Marshall, A. (2004). *Principles of economics*. Digireads. com Publishing.

Penn, G., & A. Haynes (2009). *The law and practice of international banking*. Sweet & Maxwell Ltd..

Shekhar, K. C. (2009). *Banking Theory and Practice, 19E*. Vikas Publishing House Pvt Ltd.

## B. Stat.- 205
## Real Analysis
## Full marks – 100

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lectures - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of the course**

To provide a continuation of the study of introductory Real Analysis started in B.Stst-105. With emphasis on the transition from one to several variables and from real-valued to vector-valued functions. The course is designed to fill the gaps left in the development of calculus as it is usually presented in and elementary course. And to provide the background required for insight into more advanced level in pure and applied mathematics.

**Objectives of the Course**

On successful completion of the course, a student should be able to understand.

- different classes of sets;
- sequence of real numbers, its properties;
- series of real numbers, its convergence and different tests of convergence of a series;
- the differential calculus of vector-valued functions of several variables, differential of a vector-valued function as a linear transformation;

- Riemann integration;
- integral calculus of real-valued functions of several variables and multiple integrals;

**Learning Outcomes**

At the end of this course, the students will be able to know

- open set, compact set, monotonocity and additive class of sets;
- sequence and series of real numbers, their convergence properties;
- differential calculus for function of several variables and their application in optimization;
- Riemann integration, its existence and applications;
- multiple integrals.

## Course Content

**Set and Metric Space:** Open set, Dense Set, Countability, Compact and connected sets, Monotonic class of sets, Additive class of sets, Metric space, continuous functions of metric spaces, Application of metric spaces in statistics.

**Sequences:** Introduction to sequences, monotonic sequence, bounded sequence, convergence sequence, properties of sequence, Cauchy's sequence.

**Series:** Introduction, Convergence principle, Convergence and absolute convergence of series, Cauchy's convergence, Comparison test, Ratio test, Root test, Integral test, Abel's Lemma, Dirichlet's test, Abel's test for conditional convergent power series, Rearrangement of absolute convergent series, Multiplication of absolutely convergent series.

**Vector Valued functions of several variables:** Introduction, Linear transformation and matrices, Continuity and differentiability of transformations, The inverse function theorem, The implicit function theorem.

**Vectorization and Matrix Differentiation:** Definition, Function of matrices, Differentiation of different types of matrix functions with respect to vector and matrix, Differentiation of quadratic form.

**Riemann Integral:** Introduction, Geometrical interpretation, The existence of the Riemann integral of a continuous function, Simple properties, First and second mean value theorem, Convergence and absolutely convergence of improper and infinite integrals, Term by term integration and differentiation.

**Multiple Integral:** Double integral, Triple integral, Line and surface integral.

**Main Books Recommended**

Parzynoski and Zipse (1987): Introduction to Mathematical Analysis, McGraw Hill, N.Y.

Spiegel, M. R. (1974): Advanced Calculus, Schaum's Outline Series, McGraw-Hill, N.Y.

Trench, W. F. ((2012): Introduction to Real Analysis, Free Hyperlinked Edition 2.01

**References:**

Apostol, T. (1992): Mathematical Analysis, McGraw Hill, N.Y.

Binmore,G.H. (1965): Foundation of Analysis, Books I & II, C.U.P., London

Burkill, J.C. (1962): A First Course in Mathematical Analysis, C.U.P., London

Courant, H. (1988): Differential and Integral Calculus, Vol. II & III, Blackie.
Hardy, G.H. (1983): A First Course in Pure Mathematics. C.U.P., London
Rudin, W (1976): Real Analysis, Academic Press, N.Y.

## B. Stat.-206
## Differential Equation and Linear Algebra
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lectures-Minimum 60**

**(Duration of Examination: 4 Hours)**

**Aim of this course**

- Describing the origin and basic knowledge of differential equations, Laplace transforms and Linear algebra
- Developing problem solving skills on differential equations, Laplace transforms and Linear algebra
- Studying the existence-uniqueness and other behaviors of solutions of a large class of differential equations, Laplace transforms and Linear algebra
- Describing the solution procedure of differential equation using inverse Laplace transform
- Discussing the application of differential equations, Laplace transforms and Linear algebra in various fields

**Objectives of this course**

- To introduce students to the origin and use of differential equations, Laplace transform and Linear algebra
- To provide the basic knowledge about differential equations, Laplace transform and Linear algebra
- To provide the standard methods for solving differential equations, as well as methods based on the use of matrices or Laplace transforms
- To demonstrate how differential equations can be useful in solving many types of problems
- To develop numerical methods for solving differential equations

**Learning outcomes of this course**

At the end of the course, students should:

- have an enhanced knowledge and understanding of differential equations, Laplace transforms and Linear algebra
- be better able to use differential equation models to solve practical problems
- be able to apply Laplace transforms for any real problem and data
- be able to solve differential equations using Laplace transform methods

**Course Content**

**Differential Equation:** Basic concept, classification, origin and application of differential equation (DE), Nature and methods of solution, Initial and boundary value problems, Existence of solutions.

**First-Order Differential Equation:** Standard forms of first-order and exact DEs, Integrating factors, Separable and homogeneous equations, Linear DE, Bernoulli equations, Applications of first-order DE- orthogonal and oblique trajectories.

**Higher-Order Differential Equation:** Definition and basic existence theorem, Homogeneous equations, Reduction of order, Non-homogeneous equations, Homogeneous linear equation with constant coefficients, Method of undetermined coefficients, Variation of parameters, Cauchy- Euler equation, Application of DE in statistics.

**Linear Algebra:** Introduction, Systems of linear equations, Row reduction, Linear combinations, Markov chains: An application of matrix-vector multiplication, matrix products, span of a set of vectors, systems of linear equations revisited, Linear independence, Matrix algebra, Determinant and inverse of matrix and their applications in statistics.

**Laplace and Inverse Laplace Transformation**: Introduction, General properties, Function - Piecewise continuous, gamma, Bessel, Heaviside, Dirac delta, Periodic, Change of scale properties, Derivatives, Integrals, Multiplication by power, Initial and final value problems, Laplace transforms of systems, Applications of Laplace transformation to differential equations, and in statistics.

**Main Books Recommended:**

Boelkins, M. R., J. L., Goldberg & M. C. Potter (2009). *Differential equations with linear algebra*. Oxford University Press USA.

Ross**,** S.L. (1989). *Differential Equations*, 4th ed., Wiley, N.Y.

**References:**

Arendt, W., C. J. Batty, M. Hieber, & F. Neubrander (2011). *Vector-valued Laplace transforms and Cauchy problems*. Springer.

Ayres, F. (1997). *Differential Equations*, Schaum's Outline Series, McGraw-Hill, NY.

Goodge, S.M. (2000). *Differential Equations and Linear Algebra*, Prentice Hall, N.J., USA.

Hirsch, M. W., S. Smale and R. L. Devaney (2004). *Differential Equations, Dynamical Systems*, and an Introduction to Chaos, Amsterdam, Elsevier.

## B. Stat.- 207
## Computer Programming
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of lectures - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of this course**

This course is designed to provide basic concepts of computer and programming languish and practices in computer.

**Objectives of this course**

- develop the basic concept of C and R programming language.
- design an algorithmic solution for a given problem

- Write maintainable C and R program for a given algorithm
- knowledge of basic principles of imperative and structural programming
- understanding a function concept and how to deal with function arguments and parameters

**Learning outcomes of this course**

At the end of the course the students will be able to

- understanding of a programming language syntax and its definition by example
- understanding foundation concepts of different programming languages
- explain the process of problem solving using computer programming language
- ability to write simple programs in C language and R by using basic control structures (conditional statements, loops, switches, branching, etc.)
- Write C and R programs for simple applications of real life and Statistical computation.

## Course Content

**Programming:** Meaning, Algorithms, Flowcharts, Idea of different programming languages.

**Programming in C**: Introduction, Importance, Basic structure, Programming style, Execution of program, Sample programs.

**Sequential Structure:** Overview, Character set, Data types, Classes of data, Arithmetic operations, Expressions, Assignment statements, Input and output.

**Selective Structure:** Overview, Relational operations, Logical operations, Conditional statements, Repetitive structure, Functions, Arrays, Pointers, Structure, Statistical computation using C.

**Data Analysis with R:** Overview, Essentials of R and packages, Basic operations, Lists and data frames, Loops and conditional execution, Functions, Data visualizations and graphics, Simple statistical models, Distribution fitting, Computation concerning linear algebra and numerical optimization.

**Introduction to Maple.**

**Main Books Recommended:**

Klapper, J. H. (2011). *Introductory Statistics with R*.

Gottfried, B. S. (2005). *Theory and Problems of Programming With C*, 2nd ed., McGraw Hill. N.Y.

**References:**

Chambers, J. (2008). Software for data analysis: programming with R. Springer.

Dalgaard, P. (2008). Introductory Statistics with R, 2nd ed., Sprihger.

Press, W.H., W.T. Vetterling and S.A. Teukolsky (1992). *Numerical Recipes in C*, the Art of Scientific Computing, 2nd ed., Cambridge University Press, London.

**B. Stat. - 208**
**Practical**
**Full Marks - 150**
(70% for Practical Exam. and 30% for continuous Lab assessment)
**(Five sessions, each of Four hours durations)**

Practical problems of all sessions will be performed using programming languages C/R/software packages SPSS/ STATISTICA/EViews/Minitab/ SAS/STATA/S-Plus.

**Session I: Sampling Distributions and Order Statistics (Related to B. Stat.- 201) (Marks 30)**

1. Plotting of binomial, Poisson, Normal, gamma, beta, exponential, Weibull and Cauchy distribution.
2. Distribution of probability integral.
3. Sampling from binomial, Poisson, Normal, gamma, beta, exponential, Weibull and Cauchy distribution and obtain the sampling distribution of sample mean, sample variance, sample skewness, sample kurtosis and other relevant statistic.
4. Sampling from different parents distributions and obtain the distributions of different order statistics.
5. Sample distribution of the ratio of two independent normal variates.
6. Sampling from a bivariate normal distribution and obtain the sampling distribution of the correlation coefficient for null case.

**Session-II: Regression Analysis (Related to B. Stat.-202) (Marks 30)**

1. OLS estimation of general linear regression model.
2. Detection of multicollinearity and remedial measures.
3. Fitting of polynomial regression model, orthogonal polynomial.
4. Regression with dummy independent variables
5. Detection of heteroscedasticity and GLS estimation of the model.
6. Detection of autocorrelation and remedial measures.

**Session-III: Analysis of Variance and Experimental Design (Related to B. Stat.-203) (Marks 30)**

1. A visit to local research lab/institute.
2. Analysis of variance for one way, two way and three way classified data.
3. Analysis of variance of CRD, RBD and LSD.
4. Estimates of one missing value in RBD and LSD and ANOVA of these designs.
5. Analysis of factorial experiments and total and partial confounding.
6. Covariance analysis of one way and two way classified data with one concomitant variable.
7. Final visit to the local research lab/institute and write down a report on the activities of the lab/institute.

**Session-IV: Economics and Financial Statistics (Related to B. Stat.- 204) (Marks 30)**

1. Computation and solution problems associated with demand, supply, elasticity, and market equilibrium.

2. Numerical illustrations of GDP, GNP, unemployment rate, per capita income, household consumption, inflation and consumer price index
3. Computation and numerical illustrations of maximum insurance premium and expected loss for different utility function, Life table and life insurance, Benefit and Risk.
4. Estimation of systematic risk, nonsystematic risk and VaR, Comparison of risk measures, Portfolio optimization.

**Session-V: Computer Programming (Related to B. 102-104,106, 207) (Marks 30)**

1. Computation of various measures of central tendency. Dispersion: range, standard deviation, mean deviation, first four moments, skewness and kurtosis from ungrouped data.
2. Correlation and regression for two variables. Fitting of Binomial and Poisson distributions.
3. Matrix operation: Transpose, Addition, Subtraction, Multiplication and Inversion.
4. Solution of simultaneous equations.

**B. Stat.- 209**
**Viva-voce and Presentation**
**Full Marks-100**

## B. Sc. Honours, Part – III, 2020

**B. Stat.- 301**
**Multivariate Distribution**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of this course**
This course is designed to provide fundamental concepts of multivariate distribution. Student gathers knowledge to identify the differences among multivariate sampling distribution, multivariate central and non-central distribution.

**Objectives of this course**
- Understand the theoretical and application based concepts of multivariate sampling distribution.
- Calculate mean vector, variance-covariance matrix for different multivariate distributions and perform inferential statistics.
- Understand multivariate normal distribution, maximum likelihood estimation, Wishart's distribution, Hotelling's $T^2$ distribution;
- Parameter estimation procedure and Hypothesis Testing for multivariate data.

**Learning outcomes of this course**
After completing this course, students will be able to
- conceptualize the basic idea of multivariate central and non-central distribution.
- explore and summarize multivariate sampling distribution
- synthesize the statistical knowledge and techniques required in multivariate sampling distribution.
- real life application of multivariate central and non-central distribution.
-

## Course Content

**Multivariate Normal Distribution:** Introduction, Marginal and conditional distributions, Moments, moment generating function and properties of multivariate normal distribution, Maximum likelihood estimation of mean vector and covariance matrix of multivariate normal distribution and their properties.

**Distribution of Quadratic Form:** Introduction, Non-central $\chi^2$, t and F distributions, Distribution of general quadratic forms, Expected values, Moments and moment generating functions, Properties of quadratic forms.

**Multivariate Sampling Distribution:** Introduction, Derivation and distribution of Hotelling's $T^2$ - statistic, properties and applications, Distribution of sample covariance matrix and sample generalized variance, Wishart distribution and its properties, Distribution of latent roots of a dispersion matrix, Multivariate t-distribution and its properties, Test for a mean vector, Test for equality of mean vectors.

**Mixture of Multivariate Distributions**: Introduction, Mixture of multivariate normal distributions and its properties, Mixture of multivariate t-distributions and its properties.

**Main Books Recommended:**

Hair, J. F., R. L. Tatham, R. E., Anderson & W. Black (2006). *Multivariate data analysis*. Upper Saddle River, NJ: Pearson Prentice Hall.

Härdle, W. K., & L. Simar (2012). *Applied multivariate statistical analysis*. Springer.

**References:**

Anderson,T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, 5th ed., Wiley, N.Y.

Johnson, R. A. and D. W Wichern (2002). *Applied Multivariate Statistical Analysis*, 5th ed., Prentice Hall, N.Y.

Nachtsheim, C. J., J., Neter & W. Li (2005). *Applied linear statistical models*.

Richard, A. J., & W. W. Dean (2002). *Applied multivariate statistical analysis*. Prentice Hall, New York.

## B. Stat.- 302
## Estimation
## Full marks – 100
## (Examination 80, Tutorial/Terminal 15, and Attendance 5)
## Number of Lectures - Minimum 60
## *(Duration of Examination: 4 Hours)*

**Aim of the Course**

Students should have enough understanding of the main concepts and algorithms of estimation theory for practical application as well as for their research.

**Objectives of this Course**

- Understand all properties of a good estimator with application.
- Understand various methods of point estimators and their characteristics.
- Understand interval estimators, confidence intervals and confidence limits.
- Understand optimality properties of Bayesian estimators.

**Learning Outcomes of this Course**

At the end of the course, the students will be able to

- Know to use the appropriate method in any estimation problem.
- Have ability to apply estimation methods to real life of problems.
- Know to detect the best estimates.
-

**Course Content**

**Point Estimation:** Principle of point estimation, Consistency, Unbiasedness, Efficiency, Sufficiency, Asymptotic efficiency, Minimum variance bound estimate, Cramer-Rao lower bound.

**Methods of Point Estimation:** Introduction, Estimation methods**–**moments, maximum likelihood, minimum chi-square, least squares and Bayesian, with their properties, Minimax estimators, Point estimators concerning Bernoulli, binomial, Poisson, geometric, uniform, normal, exponential, gamma, beta and Weibull distributions.

**Robust Estimation:** Introduction, Necessity, Robust estimation of location and scale parameters of symmetric distributions, Trimmed and Winsorized means, Linear combination of selected order statistics, M, L and R-estimators.

**Nonparametric Estimation:** Basic ideas and methods of nonparametric estimation.

**Interval Estimation:** Concepts of central and non-central confidence intervals, Estimation methods**–** Neyman classical, pivotal quantity, large sample, Bayesian and Fiducial, Confidence intervals for parameters of Bernoulli, binomial, Poisson, geometric, uniform, normal, exponential, gamma, beta and Weibull distributions.

**Main Books Recommended:**


Brunk, H. D., & T. Teichmann (2009). *An introduction to mathematical statistics*. Physics Today, 13(11), 50-52.

Hogg, R. V. and A.T. Craig (2002). *Introduction to Mathematical Statistics*, 5th ed., Pearson Education, Singapore.

Mood, A.M., F. A. Graybill and D.C. Boes (1994). *Introduction to the theory of Statistics.* 5th ed., McGraw**–**Hill, N.Y.


**References:**


Casella, G., & R. L. Berger (2002). *Statistical inference*. Pacific Grove, CA: Duxbury.

Kendall, M.G. and A. Stuart (2004). *Advanced Theory of Statistics*, 14th ed., Edward Arnold, N.Y.

Lehmann, E.L. and G. Cassela (1998). *Theory of Point estimation*, Springer Verlag, N. Y.

Rao, C. R. (2009). *Linear statistical inference and its applications*. John Wiley & Sons.


## B. Stat. - 303
## Hypothesis Testing
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lecture - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of this Course**

Hypothesis testing is an important subject and step in all spheres of data analysis. The course aims at providing the basics of hypothesis testing with emphasis on some commonly encountered hypothesis tests in statistical data analysis such as in comparisons of averages, testing for variability, proportions and significance. This course will also introduce parametric and nonparametric test including simple and composite hypothesis. Various test methods are introduced for testing hypothesis of

statistical data. This course will walk through the basics of statistical thinking and will teach the correct statistical tool to help answer our questions of interest.

**Objectives of this course**

- Understand the fundamentals of hypothesis tests (examples might include one and two tailed hypotheses, types of errors, significance levels and p-values).
- Be able to interpret an applied problem, selecting the correct hypothesis test.
- Interpret mathematical models such as formulas, graphs, tables and schematics and draw inferences from them.

**Learning outcomes of this course**

Today hypothesis testing constitutes the major foundation of data analysis. Through this course student will be able to

- Validate parametric and non-parametric test for simple and composite hypothesis.
- Use computers and the software package Excel, SPSS and R as a tool for data management and hypothesis testing.
- Draw valid conclusions about hypotheses from the results of different statistical tests.
- Justify conclusions even when no scientific theory exists.
-

**Course Content**

**Test of Significance:** Basic concept, Idea of null and alternative hypotheses, Standard error, Test procedures, Probability value, Test of single proportion, mean and variance, Comparison of two and more proportions, means and variances, Test for correlation and regression coefficients, Test for independence and association of attributes in r x c contingency tables, Fisher's exact test in 2 x 2 contingency table, Test for association in three-way contingency tables, Small sample tests of significance, Large sample tests.

**Parametric Test:** Basic concept, Simple and composite hypotheses, Errors in hypothesis testing, Critical region, Size of the test, Power, Best critical region (BCR), Power function, Power curve, Neyman-Pearson fundamental lemma, Most powerful critical region and test, Uniformly most powerful test, Two-sided BCR.

**Non-parametric Test:** Basic concept. Sign, Run, Rank Sum, Randomization, Kolmogorov-Smirnov one and two samples, Kruskal-Wallis, Wilcoxon matched-pairs signed rank, Median, Mann-Whitney U, Rank correlation and goodness of fit tests.

**Likelihood Ratio Test**: Principles of likelihood ratio (LR) test, Distribution of LR statistic, Asymptotic distribution of LR statistic, Application of LR test, LR test in linear model.

**Sequential Test:** Introduction, SPRT, OC and ASN functions. Exercise on Binomial, Poisson, Normal and Exponential distributions.

**Bayesian Hypothesis Testing:** Introduction, Test of hypothesis concerning Normal and Exponential distributions in predictive approach.

**Main Books Recommended:**

Hogg, R. V. and A. T. Craig (2002): I*ntroduction to Mathematical Statistics*, 5th ed., Pearson Education, Singapore.

Kendall, M.G. and A. Stuart (2004). *Advanced Theory of Statistics*, 14th ed., Edward Arnold, N.Y.

Miller, W. (2013). *Non-Parametric Statistics*. Springer New York.

**References:**

Casella, G., & R. L.Berger (2002). *Statistical inference*. Pacific Grove, CA: Duxbury.

Gibbons, J. D., & S. Chakraborti (2011). *Nonparametric statistical inference* (pp. 977-979). Springer Berlin Heidelberg.

Härdle, W. K., V., Spokoiny, V., Panov, & W. Wang (2014). *Testing a Statistical Hypothesis.* In Basics of Modern Mathematical Statistics. Springer Berlin Heidelberg.

Lehmann, E. L. (2000). *Testing of Statistical Hypothesis*. 4th ed., Wiley, N.Y.

Mukhopadhaya, N. (2000). *Probability and Statistical Inference*, Marcel Dekkar, N.Y.

Rao, C. R. (2009). *Linear statistical inference and its applications*. John Wiley & Sons.

Siegel, S. and N. J. Castellan (1988). *Nonparametric Statistics for the Behavioral Sciences*, McGraw-Hill, N.Y.

## B. Stat.- 304
## Advanced Regression
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lecture - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of the course**

The aim of this course is to provide you with an overview of the most common techniques used to quantify logistic regression, quantile regression and robust regression analysis and to handle binary variables, outliers etc.

**Objectives of the course**

After completing this course, the student should

- understand the feathers of various logistic regressions
- apply and fit appropriate regression model according to the nature of the data
- analyzing results with unusual observations

**Learning Outcomes**

At the end of the course, the student will be able to

- know when it is appropriate to use a regression model.
- how to interpret results from logistic regression models
- how to present results from regression models in publication-quality tables.
- think about how to interpret and evaluate the regression-based research of others, and how to produce their own unique research based on regression.

## Course Content

**Non-linear Regression:** Introduction. Different types, Polynomial and orthogonal regression models. Models with one or more than one explanatory variables, Transformation of the models, Analytical methods for selecting a transformation, Box and Cox transformation.

**Binary Variables and Logistic Regression:** Generalized linear models, Dose response models, General logistic regression model, Goodness of fit statistics, Residuals.

**Nominal and Ordinal Logistic Regression:** Introduction, Multinomial distribution, Normal logistic regression, Ordinal logistic regression, General comments.

**Count Data, Poisson Regression and Log-linear Models:** Introduction. Poisson regression. Examples of contingency tables. Probability models for Contingency tables. Log-linear models. Inference for log-linear models.

**Quantile Regression:** Introduction, Methods**–**quantile, Inter-quantile, simultaneous quantile and bootstrapped quantile regressions, Influential observations, Outlier, High leverage points.

**Robust Regression:** Group deletion, Masking and swamping, Breakdown point and Robust estimators, Least median of squares technique, Reweighted least squares residuals, Detection of multiple outliers.

**Stochastic Regression:** Introduction, Asymptotic properties of OLS estimators, Errors in variable and Errors in equation, Specification error, Instrumental variable in regression analysis.

**Main Books Recommended:**


Montgomery, D. C., E. A., Peck & G. G. Vining (2012). *Introduction to linear regression analysis* (Vol. 821). John Wiley & Sons.

Ryan, T. P. (2008). *Modern regression methods* (Vol. 655). John Wiley & Sons.

Weisberg, S. (2014). *Applied linear regression*. John Wiley & Sons.


**References:**


Birkes, D. & Y. Dodge (2011). *Alternative methods of regression* (Vol. 190). John Wiley & Sons.

Chatterjee, S., & A. S. Hadi (2009). *Sensitivity analysis in linear regression* (Vol. 327). John Wiley & Sons.

Cook, R.D. and S. Weisberg (1982). *Residuals and Influence in Regression*. Chapman and Hall, London.

Johnston, J. (1997). *Econometric Methods*, 4th ed., McGraw-Hill, N.Y.

Draper, N. R. and H. Smith (2003). *Applied Linear Regression*, 3rd ed., Wiley, N.Y.

Gujarati, D. N. (2012). *Basic econometrics*. Tata McGraw-Hill Education.

Rousseeuw, P. J., & A. M. Leroy (2005). *Robust regression and outlier detection* (Vol. 589). John Wiley & Sons.

Seber, G. A. F. and Wild (1989). *Nonlinear Regression*, Wiley, N.Y.

**B. Stat.- 305**
**Stochastic Process**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**The aim of this course**
The aim of the course is to bridge the gaps between the elementary probability texts and that of the excellent advanced works on probability theory. It deals with the families of random variables which are functions of time. Also accommodate the methods and applications of stochastic processes.

**Objectives of this course**
After completion of the course, the students should
- Understand the self-contained modules of concepts and notations.
- Understand all the features of probability distributions and stochastic processes.
- Gather knowledge, how uncertainties arises in several ways in physical and biological processes.

**Learning outcomes of this course**
At the end of the course, the students will be able to
- Know when it is appropriate to use probability generating function.
- Know how phenomenon is occurring in physical and life sciences not only as a random phenomenon but also changing with time or space.
- Clear the concept of Andrei Andreivich Markov chain, statistical inference about Markov chains.
- Elements of stochastic processes with applications to the natural sciences.
- Markov processes with discrete and continuous state space.
-

**Course Content**

**Generating Function:** Basic concept, Convolution, Bivariate generating function, Continuity theorem.

**Limit Theorem:** Mutual independence of random variables, Convergence of sequence of random variables.

**Recurrent Event:** Introduction, Renewal equation, Delayed recurrent event, Number of occurrences of a recurrent event, Application to the theory of success runs.

**Random Walk and Ruin Problem:** Classical ruin problem, Expected duration of game, Generating functions for duration of game and for first-passage times.

**Markov Chain:** Transition matrix, Higher transition probabilities, Classification of states and chains, Ergodic properties, Evaluation of $P^n$.

**Finite Markov Chain:** General theory of random walk with reflecting barriers, Transient states, Absorption probabilities, Application to recurrence times, Ideas of hidden Markov model.

**Homogeneous Markov Process:** Poisson process, Simple birth process, Simple death process, Simple birth**–**death process, Effect of immigration. Queuing process,

Single server queues, Equilibrium theory, Queues with many servers, Limiting properties of queues.

**Point Process:** Stationary point process, Renewal process, Doubly stochastic process.

**Branching Process:** Structure of process, Age dependent branching process, Branching renewal process.

**Main Books Recommended:**


Gikhman, I. I., & A. V. Skorokhod (2004). *The Theory of Stochastic Processes*. Springer.

Medhi, J. (1994). *Stochastic Processes*, 2nd ed., Wiley Eastern Limited.

Ross, S. M. (2001). *Stochastic Processes*, Academic Press, N.Y.


**References:**


Cox and Miller (1985). *The Theory of Stochastic Process*, 2nd ed., Chapman and Hall, London.

Feller, W. (2008). *An introduction to probability theory and its applications* (Vol. 2). John Wiley & Sons.

Krishnan, V. (2006). *Probability and random processes* (Vol. 3). John Wiley & Sons.

Lund, R. B. (2003). *Elements of Applied Stochastic Processes*. *Journal of the American Statistical Association*, *98*(464), 1085-1086.

Prabhu (1980). *Stochastic Process*, Springer Varleg. N.Y.

Srinivasan, S. K., & A. Vijayakumar (2003). *Stochastic point processes*. Alpha Science Int'l Ltd..


## B. Stat. - 306
## Sampling Technique
**Full marks – 100**

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lectures - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of the Course**

The course will deepen your knowledge about sample surveys and their planning. The aim of this course is to cover sampling design and analysis methods that would be useful for research and management in many fields. A well designed sampling procedure ensures that we can summarize and analyze data with a minimum of assumptions and complications.

**Objectives of the course**

In this course, we'll cover the basic methods of sampling and estimation and then explore selected topics and recent developments.

- This course starts with an introduction to sampling; we then provide an overview to sampling; and the distinction between probability sampling and non-probability (e.g., quota) sampling is discussed.
- we then proceed to talk about how to estimate population mean, population total and population proportion under simple random sampling, stratified sampling, systematic sampling and cluster sampling (with associated estimation and confidence interval methods)
- We focus how to use auxiliary information about the population to estimate unknown population parameters of interest in ratio and regression estimation
- We also covered some recently developed non-probability sampling designs

**Learning Outcomes**

After completing the course students should be able to

- explain the advantages and disadvantages of standard sampling designs
- choose appropriate sampling designs for different selection problems
- choose suitable estimators depending on the problem and the access to auxiliary information
- carry out estimation and precision estimation on data from some standard sampling designs with and without auxiliary information
- describe and practically use some basic estimation methods for non-probability problems

## Course Content

**Sampling:** Introduction and preliminaries, Sample survey and complete enumeration, Steps in a sample survey, Planning of sample survey, Sampling and non-sampling errors, Bias, Accuracy and Precision, Probability and nonprobability sampling.

**Probability Sampling:**

**Simple Random Sampling:** Introduction, Simple random sampling with and without replacement, Drawing a simple random sample, Estimation of population characteristics- mean, total**,** proportion, and their confidence intervals, Determination of sample size.

**Stratified Random Sampling:** Introduction and principles of stratification, Estimation of population mean, total and their variances, Allocation of sample size in different strata, Ideas of post and deep stratifications.

**Systematic Sampling:** Linear and circular systematic sampling, Estimation of mean, total and their variances, Sample size determination, Comparison of systematic sampling with other sampling methods, Two-dimensional systematic sampling.

**Cluster Sampling:** Cluster sampling with equal and unequal size, Estimation of mean, total and their variances, Determination of cluster size, Estimation of mean and its variance, Optimum allocation of sample size at different stages.

**Use of Auxiliary Information:** Ratio, Difference, Regression and Product methods of estimation, Estimation of the population parameter and their variances, Mean square error, Separate, combined, ratio and regression estimators, Comparison of the estimators.

**Non-probability Sampling:**

Purposive sampling, Judgment sampling, Quota sampling, Convenience sampling. Snowball sampling, Merits, Demerits and applications.

**Main Books Recommended:**

Cochran, W. G. (2007). *Sampling techniques*. John Wiley & Sons.

Mukhopadhyay, P. (2009). *Theory and methods of survey sampling*. PHI Learning Pvt. Ltd..

**References:**

Chaudhuri, A., & H. Stenger (2010). *Survey sampling: theory and methods*. CRC Press.

Lohr, S. (2009). *Sampling: design and analysis*. Cengage Learning.

Raj, D. and P. Chandhok (1998). *Sample Survey Theory*, Norosa publishing house, New Delhi.

Särndal, C. E., B. Swensson, & J. Wretman (2003). *Model assisted survey sampling*. Springer.

Scheaffer, R., W. Mendenhall III, R. Ott, & K. Gerow (2011). *Elementary survey sampling*. Cengage Learning.

Singh, D. and F. S. Chaudhary (1986). *Theory and Analysis of Sample Survey Designs*, Wiley Eastern Ltd.

## B. Stat.- 307
## Complex Variable and Transformation
**Full Marks-50**

(Examination 40, Tutorial/Terminal 7.5, and Attendance 2.5)

**Number of Lectures - Minimum 30**

***(Duration of Examination: 3 Hours)***

**Aims of this Course**

The aims of this course are to gather more knowledge regarding fundamental concepts, techniques and theories of complex algebra, calculus and geometry that are frequently used in real life data or in any branch of science.

**Objectives of this Course**

After completing this course, the students should

- learn domain, range, limit, continuity and differentiability of a function along with the categories of functions;
- learn to formulate, identify and solve differential equations using several methods under boundary conditions or initial conditions.
- learn techniques of complex analysis that make practical problems easy;
- improve the ability to work with mathematical problems;

**Learning outcomes of this course**

On successfully completion of this course, the student will be able to

- know the functions of complex variable and concepts of continuity, differentiability and analyticity of such functions;
- the ability to analyze data with appropriate mathematical tools and techniques;
- develop the ability to think critically by verifying mathematical conjectures and launching theorems from complex analysis.

**Course Content**

**Complex number**: Introduction, Properties of complex numbers, Differences with real number.

**Complex functions:** Different functions, limit and continuity, Complex differentiation and Cauchy Riemann equations.

**Complex integration**: Cauchy's integral, Morera's, Liouville's, Rouches's. Taylor's, Laurant's and Residue theorems. Evaluation of integrals, Elementary conformal transformations, Characteristic functions.

**Transformations:** Fourier, Hilbert and Wavelets transforms, and their applications.

**Main Books Recommended:**

Fokas, A. S. (2003). *Complex variables: introduction and applications*. Cambridge University Press.

Lipschutz, S., J. J. Schiller, & D. Spellman (2009). *Schaum's Outlines: Complex Variables: with an Introduction to Conformal Mapping and Its Applications*. McGraw-Hill.

**References:**

**Fisher, S. D. (1999). *Complex variables*. Courier Dover Publications.**

Polyanin, A. D., & A. V. Manzhirov (2006). *Handbook of mathematics for engineers and scientists*. CRC Press.

Ponnusamy, S., & H. Silverman (2006). *Complex variables with applications*. Boston: Birkhäuser.

Poularikas, A. D. (2009). *Transforms and applications handbook*. CRC press.

## B. Stat. - 308
## Simulation and Modeling
## Full Marks – 50
## (Examination 40, Tutorial/Terminal 7.5, and Attendance 2.5)
## Number of Lectures - Minimum 30
## *(Duration of Examination: 3 Hours)*

**Aim of the Course**

The goal of this course is to introduce students to basic simulation methods and tools for modeling and simulation of continuous, discrete and combined systems, and provide the foundations for the student to understand computer simulation needs, and to implement and test a variety of simulation and data analysis libraries and programs.

**Objectives of the Course**

Students should know how to:

- Generate random number and random variables

- Use Monte-Carlo technique to solve intractable mathematical problems
- Build a simulation model with basic operations and inputs
- Build a simulation model with detailed operations
- Develop algorithm and computer programing for intended simulation
- Perform statistical analysis of output from simulation

**Learning Outcome**

Having completing this course, students will able to do:

- Understand the definition of simulation and how to develop and analyze a simulation model
- Understand the fundamental logic, structure, components and management of simulation modeling
- Understand the scope and limitations of simulation
- Construct simulation models for real-world systems
- System analysis and benchmarking
- Evaluate performance of existing and new/proposed models real-world systems

## Course Content

**Introduction to Simulation:** Basic concepts of systems, models, and simulation, Discrete and continuous systems simulation, Purposes of simulation, Advantages and disadvantages of simulation, Steps in a simulation study.

**Probability Simulation and Monte Carlo Method:** Concept of random numbers, Techniques for generating random numbers, Tests for random numbers. Methods for generating random variates–inverse transformation, composition, convolution, acceptance-rejection. Comparison of the methods, Applications of probability distributions in simulation–Uniform, Exponential, Weibull, Gamma, Normal, Binomial, Poisson, Monte Carlo integration. MCMC method.

**Verification and Validation of Simulation Models:** Simulation credibility, Techniques for verification and validation of simulation models, Statistical methods for comparing real-world observations and simulation output data.

**Analysis of Simulation Data:** Identifying the distribution with data, Parameter estimation, Goodness-of-fit tests, Output analysis for terminating and steady state simulations.

**Simulation Case Studies:** Application of simulation in queuing and inventory systems.

**Main Books Recommended:**

Lazic, S. E., & H. L. Roche (2012). *Introducing Monte Carlo Methods with R*.

Rubinstein, R. Y., & D. P. Kroese (2011). *Simulation and the Monte Carlo method* (Vol. 707). John Wiley & Sons.

**References:**

Banks, J. (1998). *Handbook of Simulation*, Wiley, New York.

Law, A. M., & W. Kelton (2000). *Simulation modeling and analysis*. Mac Graw Hill, Boston, Burr Ridge, ua.

Robert, C. P. and G. Casella (2010). *Introducing Monte Carlo Methods with R* (Vol. 18). New York: Springer.
Ross, S. M. (2006). *Simulation*, 4th ed., Academic Press.
Sing, V. P. (2009). *System Modeling and Simulation*, New Age International (P) Limited, New Delhi.
Suess, E. A. and B. E. Trumbo (2010). *Introduction to Probability Simulation and Gibbs Sampling with R*, Springer.

**B. Stat. - 309**
**Practical**
**Full Mrks-250**
(70% for Practical Exam. and 30% for continuous Lab assessment)
**(Six sessions, each of Five hours durations)**

Practical problems of all sessions will be performed using programming languages C/R/software packages SPSS, STATISTICA, EVIEWS, MINI-TAB, SAS, STATA.

**Session-I: Estimation (Related to B. Stat.- 302) (Marks 45)**
1. Point estimation methods-maximum likelihood, moments, least squares, minimum chi-square and Bayesian.
2. Construction of confidence intervals for the parameters of binomial, Poisson and normal.
3. Large sample confidence interval, Bayesian interval.
4. Robust estimation.

**Session-II: Hypothesis Testing (Related to B. Stat.- 301 and 303) (Marks 45)**
1. Small sample test of significance based on $\chi^2$, t and F distributions. Tests for several means and variances
2. Test for independence and association in contingency table, exact test in a 2 x 2 contingency table.
3. Test of hypothesis of parameters of Binomial and Normal distribution.
4. Power function and power curves.
5. Likelihood ratio tests.
6. Large sample test of significance.
7. SPRT, OC and ASN function.
8. Bayesian hypothesis testing.
9. Test for a mean vector
10. Test for equality of mean vectors.

**Session-III: Advanced Regression (Related to B. Stat.-304) (Marks 45)**
1. Analysis of residuals detection of influential observation and high leverage points and outliers.
2. Analysis related to quantile, inter-quantile, bootstrapped quantile regression methods.
3. Analysis related to robust regression.

4. Regression on dummy dependent variable-fitting of linear probability, logit, probit and tobit models, and logistic regression models.
5. Analysis related to stochastic regression-instrumental variable techniques.

**Session-IV: Stochastic Processes (Related to B. Stat.- 305) (Marks 45)**

1. Probability estimate of the denumerable Markov chain.
2. Relation between the Chapman-Kolmogorov equation and the transition probabilities of a Markov chain.
3. Determination of higher transition probabilities:
   i. Two-state Markov chain
   ii. Three-state Markov chain
4. Statistical Inference for Markov chain:
   i. Maximum likelihood estimation
   ii Hypothesis testing
5. Estimation of the parameter of Poisson process.
6. Estimate the Laplace transform of interval transition probabilities and the limiting probabilities of Markov renewal process.

**Session-V: Sampling Techniques (Related to B. Stat.- 306) (Marks 35)**

1. Drawing of random sample from finite population.
2. Estimation of population mean and standard errors using
   i. Simple random sampling.
   ii. Stratified random sampling.
   iii. Systematic sampling.
   iv. Cluster sampling with equal size.
   v. Ratio, regression and product method of estimation.
3. Determination of the optimum size of the sample and optimum cost under various sampling procedure in 2.
4. Selection of samples in case of PPS sampling and estimation of the population parameters and their standard errors (H. T. estimators, Murthy's estimators, Des Raj estimators etc.).

**Session-VI: Simulation and Modeling (Related to B. Stat.- 308) (Marks 35)**

1. Generating random variates from different distributions.
2. Fitting Statistical models.
3. Graphical procedures for checking models.
4. Verification and validation of simulation models.
5. Properties investigation of simulated data.
6. Simulation case studies.

**B. Stat.- 310**
**Viva-voce and Presentation**
**Full Marks-100**

**B. Stat.- 401**
**Multivariate Analysis**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of the course**:
The aim of this course is twofold: to provide an overview of the most common statistical methods for multivariate analysis, and to provide the necessary information to solve the real world problems that are created due to several factors/characters/features/variables.

**Objective of the Course:**
The main objective of this course are

- to understand multivariate modeling based on real world problems;
- to learn most common multivariate statistical methods for real world data analysis;
- to develop the capability of multivariate model building strategies; and
- Hands-on training on multivariate data analysis to understand how to provide the necessary information to solve the real world problems.

**Learning Outcomes:**
After completing this course successfully, the learners/students would be able

- to analyze multivariate datasets to provide the necessary information to solve the real world problems that are associated with several factors/characters/features/variables;
- to select the appropriate statistical algorithms for analyzing multivariate datasets;
- to improve the existing statistical algorithms for analyzing multivariate datasets; and
- to develop new statistical algorithms for analyzing multivariate datasets.

## Course Content

**Principal Component Analysis:** Introduction, ML estimator of principal components (PCs) and their variances, Sampling properties, Hypothesis testing, Singular Value decomposition and its application, Application of PCs in regression analysis and clustering.

**Factor Analysis:** Introduction, Orthogonal factor model, Methods of estimation, Factor rotation and interpretation, Estimation factor scores, Testing goodness of fit, Application in regression, Clustering and Bayesian analysis.

**Independent Component Analysis**: Introduction, Information theory, Methods of ICA estimation, ICA algorithms.

**Canonical Correlation Analysis:** Introduction, Canonical correlation and varieties in population, and their estimation, Relationship with other correlation coefficients and linear regression analysis.

**Classification:** Basic principles, Classification with two or more populations using Bayes, Fisher's and logistic classifiers, Evaluation of classifiers.

**Clustering**: Introduction, Similarity measures, Hierarchical clustering methods, Non-hierarchical clustering methods.

**Main Books Recommended:**


Anderson,T.W. (2003): *An Introduction to Multivariate Statistical Analysis*, 5th ed., Wiley, N.Y.

Johnson, R. A. and D. W Wichern (2002): *Applied Multivariate Statistical Analysis*, 5th ed., Prentice Hall, N.Y.

Hyvarinen, A, J. Karhunen and E. Oja (2001): *Independent Component Analysis*, Wiley, New York.


**References:**


Fidell, L. S., & B. G. Tabachnick (2006). *Using multivariate statistics*. *New York: Harper and Row*.

Hastie, T., R. Tibshirani, J. Friedman, T. Hastie, J. Friedman, & R. Tibshirani (2009). *The elements of statistical learning*. New York: Springer.

Muirhead, R. J. (2009). *Aspects of multivariate statistical theory* (Vol. 197). John Wiley & Sons.

Schott, J. R. (2002). Principles of Multivariate Analysis: A User's Perspective. Journal of the American Statistical Association, 97(458).

Seber, G. A. (2009). *Multivariate observations*. John Wiley & Sons.

Wood, F. (2009). *Principal component analysis*.


## B. Stat. - 402
## Demography
## Full marks – 100

(Examination 80, Tutorial/Terminal 15, and Attendance 5)

**Number of Lecture - Minimum 60**

***(Duration of Examination: 4 Hours)***

**Aim of this course**

This course is planned to afford the concepts of demography and carry out different demographic techniques to measure population characteristics

**Objectives of this course**

- Improve the knowledge of demography, population studies and the nature of demographic data.
- Understand basic demographic terminology, such as morbidity, mortality, force of mortality, marriage, divorce and nuptiality.
- Estimate the different parameters of vital events.
- Construct the life table of the population
- Identify population behavior in a particular region as well as whole country.

- Differentiate age-sex composition, structure and its impact over the country and know the life durability of a country.

**Learning outcomes of this course**

At the end of the course the students will be able to

- unfold the fundamental concepts of demography.
- describing various feature and explain the requirements of demography.
- assemble information about causes of errors in age data and their detection techniques.
- Identify essential thoughts about demographic measures and their consequences.

**Course Content**

**Population Characteristics:** Meaning of demography and population studies, Nature and sources of demographic data and their uses, Basic demographic methods, Study of size, distribution, educational, economical and marital characteristics of the population, Population change, Different growth functions, Urbanization, Age and sex composition and structure, Population aging, Evaluation of age and sex data, Myer's, Whipple's, UN age- sex accuracy indices.

**Analysis of Demographic Events:** Nature, Analysis of Fertility, Fecundity, Fecundability and Reproductivity, Study of Morbidity, Mortality, Force of Mortality, Marriage, Divorce and Nuptiality, Migration, Concept of stationary, Stable and Quasi-stable Populations, Graduation of Fertility and Mortality.

**Life Table Analysis:** Basic concept, Functions and types of life tables, Construction of conventional life tables by various methods, Applications of life tables in population studies, Model life tables.

**Population Projection and Estimation:** Nature and Methodology of Population Projection and Estimation, Evaluation of the Methods, Projection of Households and Families. Demographic Transition Theory.

**Main Books Recommended:**

Biswas S. (1994). *Stochastic Process in Demography and Applications*, Wiley Eastern.

Swanson, D., & J. S. Siegel (2004). *The methods and materials of demography*. Elsevier Academic Press.

**References:**

BBS and NIPORT, All Demographic Reports.

Goldmann, G. (2010). *Principles of Demography*.

Hougaard, P., & P. Hougaard (2000). *Analysis of multivariate survival data* (Vol. 564). New York: Springer.

O'Leary, Z. (2004). *The essential guide to doing research*. Sage.

Pickard, A. J. (2013). *Research methods in information*. Facet Publ..

Preston, S. H., P. Heuveline & M. Guillot (2001). *Demography: Measuring and modeling population processes*. *Pop. Dev. Rev*, *27*, 365.

R.C. Elandt-Johnson, and N.L. Jhonson (1980). *Survival Models and Data Analysis*. Wiley, N.Y.

Shryock, H. J. S. Siegel and Associates (1980), *The Methods and Materials of Demography*, Condensed ed., Academic Press, N.Y.
Spigelman, M. (1968). *Introduction to Demography*, Harvard University Press, Cambridge, London
UNO, *Reading in Population Research Methodology*, Vol. 1 to 6.

**B. Stat. - 403**
**Biostatistics and Bioinformatics**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lecture - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of this course**
The aim of this course is to give an overview about survival analysis, medical statistics and bioinformatics.

**Objectives of this course**
- To equip the students with the methodology for analyzing censored data that arises in medical or engineering problems;
- To help the students to acquire knowledge on the theory of survival analysis and medical statistics;
- To provide basic idea in Bioinformatics;
- To nurture general statistical thinking.

**Learning outcomes of this course**
After completion of the course, students will be able to
- conduct an epidemiological or medical study.
- apply proper statistical methods and models to analyze the data from epidemiological or medical study.
- know gene sequencing, sequencing data and statistical methods and models to analyze sequencing data.

**Course Content**

**Biostatistics:** Basic concept, Failure, Intensity of failure, Lifetime, Residual life, Life table, Survivor function, Hazard function, Conditional probabilities of failure, Central failure rate and their inter-relationship. IFR, DFR, CFR, Distributions- uniform, Exponential, Weibull, Extreme value.

**Incomplete Data Analysis:** Type of censoring, Construction of likelihood function with censored data, Estimation of Parameters and their sampling variances from exponential, Weibull, and extreme value distributions using type I and type II censored data.

**Medical Statistics:** Introduction, Biological assay, Cross-sectional, Prospective and Retrospective study designs, Study of prevalence, Incidence and risk factors,

Attributable risk and relative risk, Screening test, Clinical drug trials– symptoms and cognitive factors, Randomized and most general rules, Treatment covariate interaction.

**Molecular Biology of Cell**: Introduction, Chromosome, Gene, Meiosis, Mitosis, Mandel's Laws, Linkage and Mapping, Quantitative genetics, Molecular Genetics, Genotype and Genotyping technology.

**Linkage Analysis and Map Construction**: Introduction, Mendelian segregation, Segregation patterns in a full-sib family, Two-point analysis for backcross and F2-intercross, three-point analysis, Multilocus likelihood and locus ordering, Estimation with many loci, Mixture likelihoods and order probabilities, Map functions. Linkage analysis with controlled crosses and recombinant inbred lines.

**Bioinformatics:** Basic concept and importance, Central dogma, Amino acids with its structure and functions, Codons, Protein/Amino acid sequence.

**Genome Sequencing**: Introduction to DNA/ RNA/ Protein sequence. DNA/ RNA basic and advanced sequencing methods (Maxam-Gilbert, Chain-termination, 454 pyro, Illumina, SMART, nanopore and de novo sequencing). Next Generation Sequencing (NGS) Technologies and applications. Genome Assembly (Genome assemblers and EST assemblers). De-novo vs. mapping assembly.

**Sequence analysis:** Pairwise sequence alignment and protein structure/function prediction using online databases NCBI, GenBank, EMBL, UniPort, SWISSPROT, ExPASy, PDB and software BLAST, Pfam, Clustal-Omega/ ClustalW, SMART, SABLE and SWISS-MODEL.

**Main Books Recommended:**


Armitage, P., G. Berry & J. N. Matthews (2008). *Statistical methods in medical research*. John Wiley & Sons.

Lawless, J. F. (2011). *Statistical models and methods for lifetime data* (Vol. 362). John Wiley & Sons.

Lesk, A. (2013). *Introduction to bioinformatics*. Oxford University Press.

Wu, R., C. Ma & G. Casella (2007). *Statistical genetics of quantitative traits: Linkage, maps and QTL*. Springer.


**References:**


Baxevanis, A. D., & B. F. Ouellette (2004). *Bioinformatics: a practical guide to the analysis of genes and proteins* (Vol. 43). John Wiley & Sons.

Brown, B. W., & M. Hollander (2009). *Statistics: a biomedical introduction* (Vol. 130). John Wiley & Sons.

Daniel, W. W., & C. L. Cross (2012). *Biostatistics: A Foundation for Analysis in the Health Sciences: A Foundation for Analysis in the Health Sciences*. Wiley Global Education.

Davis, J. W. (2007). *Bioinformatics and computational biology solutions using R and Bioconductor. Journal of the American Statistical Association*, *102*(477).

Fleiss, J. L., B. Levin & M. C. Paik (2013). *Statistical methods for rates and proportions*. John Wiley & Sons.

Johnson, A. D. (2008). *Bioinformatics for geneticists: a bioinformatics primer for the analysis of genetic data*.

Lee, E. T., & J. W. Wang (2013). *Statistical methods for survival data analysis*. John Wiley & Sons.
Mathur, S. K. (2009). *Statistical Bioinformatics: with R*. Academic Press.
Stuart M. Brown (2015). *Next-Generation DNA Sequencing Informatics*, Second Edition, Cold Spring Harbor Laboratory Press.

**B. Stat. - 404**
**Economic Statistics and Econometrics**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lecture - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aims of this course**
The aim of the course is formulation and specification of econometric model, estimation and testing of models and use of models.

**Objectives of this course**
- To deepen and broaden the student's knowledge.
- To cover the theory and practice of modern econometric.
- To teach the students the habits of thought knowledge understand.
- The course is application oriented.

**Learning outcomes of this course**
On successful completion of this course, students will be able to:
- understanding of material needed for empirical quantitative analysis of data relevant to development courses.
- know the modern econometrics at a level appropriate for and economic graduates, emphasizing application.
- know the emphasis will be on application of techniques for policy analysis.
-

**Course Content**

**Introduction**: Concept, scope, goals, division and policy analysis.

**National Income**: Concept, Measures, Gross domestic product, Gross national product, Net national product, National income, Personal income, Disposable income.

**Distribution of Personal Income**: Introduction, Empirical income distributions, Pareto's law, Log-normal distribution.

**Analysis of Family Budget:** Introduction, Consumer's survey, Limitations of budget surveys, Use of group means, Engel curve, Quality variation, Household composition.

**General Simultaneous Equation Model:** Identification of a structural equation, Estimation of simultaneous equation systems – OLS and LS bias, ILS, 2SLS, 3SLS, FIML and LIML methods, SURE with their asymptotic properties, Simultaneous

equations models: supply-demand, Klein-Goldberger, revised Klein-Goldberger and money-demand-supply, Models for Bangladesh economy.

**Demand Analysis**: Introduction, Basic model, Schultz's method, Price flexibility, Single commodity, Dynamic demand analysis.

**Production Function**: Introduction, Economic and statistical models, Production function, C-D and CES production functions, and their generalization, Elasticity of substitution, Cob-Web theorem.

**Main Books Recommended:**

Intrilligator, M.D. (1978). *Econometric Models, Techniques and Applications,* Prentice-Hall, N.Y.

Johnston, J. (1997). *Econometric Methods*, 4th ed., McGraw - Hill, N.Y.

Kontsoyiannis, A. (1987): *Theory of Econometrics*, 2nd ed., Macmillan Education Ltd., Hong Kong.

**References:**

Asteriou, D., & S. G. Hall (2011). *Applied econometrics*. New York: Palgrave Macmillan.

Cramer, J. S. (1960). "Empirical Econometrics", North Holland, Amsterdam.

Greene, W. H. (2003). *Econometric analysis*. Pearson Education India.

Verbeek, M. (2008). *A guide to modern econometrics*. John Wiley & Sons.

Wooldridge, J. (2012). *Introductory econometrics: A modern approach*. Cengage Learning.

**B. Stat. - 405**
**Operation Research and Quality Control**
**Full marks – 100**
(Examination 80, Tutorial/Terminal 15, and Attendance 5)
**Number of Lectures - Minimum 60**
***(Duration of Examination: 4 Hours)***

**Aim of this course**

The aim of this course is to emphasize the application of operations research for solving business problems and to introduce various statistical quality control tools and techniques which are necessary skills for a quality professional.

**Objectives of this course**

After completing this course, the students should

- understand common and important business problems;
- develop problem modeling and solving skills and learn how to make intelligent business decisions from the point of view of optimization;
- able to solve quality-related problems using different methods and tools of statistical quality control;

**Learning outcomes of this course**

At the end of the course, the students will be able to

- know how to translate a real-world problem, given in words, into a mathematical formulation;
- critically analyze and interpret results and present this in both oral and written form;
- understand the purpose and function of statistical quality control and basic concept of quality improvement.

## Course Content

**Operation Research:** Meaning and scope of operation research and basic elements of Linear Programming (LP). Mathematical concept of LP, Formulation of LP problems (LPP). Solution of LPP, Graphical and Simplex methods, Fundamental theorem of LP, Duality theorem, Sensitivity analysis, Parametric programming, Integer LP, Solution of mixed integer, Integer programming problem of cutting plane method, Transportation problem.

**Nonlinear Programming:** Introduction, Graphic solution method, General non-LPP, Mathematical background, Lagrange multipliers method, Kuhn-Tucker conditions, Quadratic programming (QP), Wolfe's modified simplex method, Beale's QPP algorithm.

**Quality Control:** Basic ideas behind manufacturing process. Meaning of statistical quality control, Process and product controls, Causes of variation in quality product. Basic principles of quality control, Control chart technique, Various attribute and variable control charts. Acceptance sampling and sampling inspection. Sampling versus screening, Sampling plans: Single, Double, Multiple and Continuous, OC, ASN, AOQ, AQQL and other Characteristics of sampling plans.

**Game Theory:** Basic concept, Two and n-persons zero-sum game, Game without saddle points, Graphic methods for 2 × n and m × 2 games, Minimax of saddle point theorems, Fundamental theorems of matrix games, Principle of dominance, Connection between games and LP.

**Main Books Recommended:**


Gupta, D. K. and M. Mohan (2001). *Linear Programming and Theory of Games*, 8th ed., Sultan Chand, New Delhi.

Montgomery, D.C. (2007). *Introduction to Statistical Quality Control, 4th ed., Wiley, N.Y.*


**References:**


Douglas, C. M. (2005). *Introduction to statistical quality control*. *John Wiley & Sons*.

*Glicksman, A. M. (2001). An introduction to linear programming and the theory of games*. Courier Dover Publications.

Intriligator, M. D. (2002). *Mathematical optimization and economic theory*. Siam.

Myerson, R. B. (2013). *Game theory*. Harvard university press.

Schilling, E. G., & D. V. Neubauer (2012). *Acceptance sampling in quality control*. CRC Press.

Spiring, F. (2007). *Introduction to Statistical Quality Control*. Technometrics.

Taha H. A. (2009). *Operations Research: An Introduction*, 10th ed., Prentice Hall, N.Y.

**B. Stat.- 406**
**Probability Measure**
**Full Marks-50**
(Examination 40, Tutorial/Terminal 7.5, and Attendance 2.5)
**Number of Lectures- 30**
**(Duration of Examination: 3 Hours)**

**Aim of this course**

To introduce the concepts of sets, classes of events, measure and integral with respect to a measure, random variables and function and probability measure to show their basic properties, and to provide a basis for further studies in Analysis, Probability, and Dynamical Systems.

**Objectives of this course**

- To describe algebra of sets, relations and the events and classes of events
- To gain understanding of the abstract measure theory and definition and main properties of the integral
- To construct Lebesgue's measure on the real line and in *n*-dimensional Euclidean space
- To explain the basic advanced directions of the theory
- To gain the knowledge of probability measure, distribution functions and expectations, convergence of random variable and distribution

**Learning Outcomes of this course**

Having successfully completed this course, students will be able to demonstrate knowledge and understanding of:

- State and prove theorems using measure theory
- Use the definition of measurable functions to prove limit theorems
- Define and use the Lebesgue integral
- Use conditional expectations and martingales
- Use product integration for calculating multivariate probability distribution functions

**Course Content**

**Sets and Classes of Events:** Algebra of sets, Relations, Open and closed set on $R^n$, Events and classes of events.

**Measure:** $\sigma$-Algebra, Measurable set, Measurability, Lebesgue measure on the real line, Properties of measures, Borel set.

**Random Variable:** Concept, Limit, Simple, Inverse, Measurable, Borel, Characteristic, Random variables as measurable functions.

**Integral of Measurable Function:** Lebesgue integral of simple, integrable, and sequences of integrable functions, General and Riemann-Stieltje's integral.

**Probability Measure:** Concept, Simple properties, Discrete, general, and induced probability spaces, Extended probability, Probability measure, Lebesgue-Stieltje's measure, Signed measure, Borel-Cantelli lemmas, Zero-one law, Kolmogorov's zero-one law.

**Distribution Function and Expectation:** Distribution function (DF) of a random variable and a random vector, Decomposition of DF's, Correspondence theorem, Expectation and its properties, moments and inequalities.

**Convergence:** Types– probability, almost sure, r-th mean, distribution and their relations, Convergence of distribution functions, characteristic functions, and moments.

**Main Books Recommended:**


Athreya, K. B., & S. N. Lahiri (2006). *Measure theory and probability theory*. Springer.

Billingsley, P. (2008). *Probability and measure*. John Wiley & Sons.

Ross, S. M. (2014). *Introduction to probability models*. Academic press.


**References:**


Folland, G. B. (2013). *Real analysis: modern techniques and their applications*. John Wiley & Sons.

Gnedenko, B.V. and A. N. Kolmogorov (1984). *Limit Distribution for Sums of Independent Random Variables*. Addison-Wesley. N.Y.

Halmos, P. R. (2006). *Measure Theory*, Sprnger-Verlag, N.Y.

Kallenberg, O. (2002). *Foundations of modern probability*. springer.

Morgan, F. (2008). *Geometric measure theory: a beginner's guide*. Academic press.

Pitt, H. R. (2012). *Integration, measure and probability*. Courier Dover Publications.

Rudin, W. (1994). *Real and Complex Analysis*, McGraw-Hill, N.Y.


## B. Stat. - 407
## Research Methodology
## Full marks – 50

(Examination 40, Tutorial/Terminal 7.5, and Attendance 2.5)

**Number of Lecture Minimum - 30**

***(Duration of Examination: 3 Hours)***

**Aim of this course**

The aim of this course is to figure out the in depth knowledge on research methodology so that a researcher can do his/her research with satisfying all steps.

**Objectives of this course**

After completing this course, the students should

- understand all the features of a complete research;
- learn how to write his/her thesis/dissertation; and
- able to write a project proposal.

**Learning Outcomes of this course**

At the end of the course, the students will be able to

- know how to write title, introduction, materials and methods, results and discussion, conclusion and recommendation of a complete research; and
- write a project proposal.

## Course Content

**Elements of Research**: Concept, definition and scope of research. Research methods and methodology, Research ethics, Desirable qualities of research, Research question, Research objectives, Research hypothesis, Operational definition.

**Research Process:** Conceptual, empirical and analytical phases of research; Problem identification, literature review, setting objectives and hypothesis, selection of research design and sample design, data gathering, data processing and analysis, and report writing.

**Questionnaire Design and Construction**: Types of questions, Framing of questions, Sequencing questions, Construction of a model questionnaire, Question wording, Guidelines for avoiding poor question wording.

**Data Processing and Analysis**: Editing, Coding, Data entry, Validation check, Imputation of variables, Tabulation plan, data analysis.

**Reliability and Validity in Measurements:** Measurement error, Test for sound measurement, Reliability and its measurements, Validity and its types, Measurements of validity; Construction of measurements scales.

**Report Writing**: Types of Reports, Design and Structure of Reports, Introductory Section, Main Body, Concluding Section, Tables and Graphical Presentations, References and Bibliography.

**Project Proposal:** Request for proposal, Term of reference, Components of a proposal, Evaluation of proposal.

**Main Books Recommended:**


C. R. Kothari: Research Methodology- Methods and Techniques, Second edition, New age International Publishers, New Delhi (2009).

M. Nurul Islam, An Introduction to Research Methods, Mullick & Brothers, Dhaka (2008).

Naresh K. Malhotra: Marketing Research – An applied Orientation, 5th Edition, Prentice Hall of India, New Delhi (2007).

Ted Palys: Research Decisions – Quantitative and Qualitative Perspectives, International Thomson Publishing; 2nd edition (1997).

Cochran W G, Sampling Techniques, 3rd Ed, John Wiley, NY (1977).

Des Raj, Sampling Theory, McGraw-Hill Series in Probability and Statistics, (1968).

Des Raj, Sampling Designs, McGraw-Hill Series in Probability and Statistics, (1972).

John & Smith, New Developments in Survey Sampling, (1969).

Kish L, Survey Sampling, Wiley Series Library, (1995).

Lohr, S. L. (2010). *Sampling: Design and Analysis*, 2nd ed., Books Cengage Learning, Australia.

**B. Stat. - 408**
**Statistics for Sustainable Development Goals**
**Full Marks – 50**
(Examination 40, Tutorial/Terminal 7.5, and Attendance 2.5)
**Number of Lectures - 30**
***(Duration of Examination: 3 Hours)***

**Aim of this course**

The aim of this course is to introduce the student to the multi-dimensional aspects of sustainable development, by looking at the historical roots and dual goals of sustainable development, and then focusing on current topics to understand how they link to development theory and the discussion how sustainable development can be affected on international, national, and local levels. Beyond the technical knowledge and skills of economic, social and environmental sustainability, there remains a debilitating gap in understanding how technical knowledge gets, or doesn't get, deployed and scaled-up into national strategies, and implemented under concrete policies.

**Objectives of this course**

This course will develop the students' ability to

- Be exposed to the relevant history of sustainable development and international attempts to address its goals.
- Understand and critically discuss important topics and concepts that are intricately linked to environment, human well-being, and sustainable development.
- discuss and articulate how sustainable development can be affected on international, national, and local levels.

**Learning Outcomes of this course**

On successfully completion of this course, the student will be able to:

- learn the concept, history and critique of sustainable development, including its significance and difficulties in policy-making contexts;
- Know how to successfully design and implement integrated SD policies, along with practical policy tools and methodologies, that overcome obstacles and accelerate transitions;
- apply those skills to areas most directly relevant to their professional practice in sector focus, political level and scale of mandate.

**Course Content**

**Introduction and Overview:** Effective aid, effective development. Alternative definitions and concepts of sustainability; views about the relationship between development activity and the environment; historical perspectives. Introduction to reflection in Statistics. The view from statistics and from other disciplines; the role of community in development; identifying the constraints to sustainable development; further views of effective development practice.

**Global Vision of Sustainable Development Goals (SDGs):** MDGs to SDGs. Introduction to Indicators for Sustainable Development Goals. Explores the

development and implementation of the UN Sustainable Development Goals from a range of theoretical, policy and practical perspectives. Country adoption within an international, domestic and global context.

**Analyze on Contemporary Issue:** International aid and technological progress, including issues of poverty, food security, healthy lives, quality education, gender equity, water availability, sustainable energy, productive employment, resilient infrastructure, reduction of inequality within and between countries, better human settlements, sustainable production and consumption, climate change action, sustainable use of oceans and terrestrial ecosystems, peaceful and inclusive societies and partnerships for sustainable development.

**Data Gap:** Identify the data gap within goals, targets and indicators of SDGs. Monitoring and evaluation of SDGs and targets. Information and Knowledge for Sustainable Development. Challenges and actions to be taken at global, regional and national level in implementing SDGs and targets. Role of statistics for achieving SDGs.

**Main Books**


Jennifer A. Elliot, (2012). An Introduction to Sustainable Development, 4th Ed, Routledge, Taylor & Francis.

Jonathan M. Harries, (2000). Basic Principles of Sustainable Development, Tuft University, USA.

Willies, K., (2011). Theories and Practices of Development, 2nd ed., Routledge, Taylor & Francis.

Hartmut Bossel, (1999). Indicators for sustainable development: Theory, Method and applications, IISD, Canada.

Data Gap Analysis of Sustainable Development Goals (SDGs): Bangladesh Perspective, (2017). General Economics Division (GED), Bangladesh Planning Commission, Government of the People's Republic of Bangladesh.


**References:**


Sustainable Development Goals-2030, The United Nations Development Program (UNDP), 2016.

Acemoglu, D. and Robinson, J.A. (2012). Why Nations Fail: The Origins of Power, Poverty and Prosperity, New York.

Series Editors: Singh, R.B., Mal, Suraj, Meadows, Michael E., (2017). Sustainable Development Goals Series, Springer International Publishing AG. Part of Springer Nature.

M.Q. Patton, (2017). Managing for Sustainable Development Goals- An Integrated approach to planning, Monitoring and Evaluation, Principles- Focused Evaluation: The Guide.

**B. Stat. - 409**
**Actuarial Statistics**
**Full Marks – 50**
(Examination 40, Tutorial/Terminal 7.5, and Attendance 2.5)
**Number of Lectures - 30**
***(Duration of Examination: 3 Hours)***

**Aims of this course**
The aim of the course is to provide grounding in statistical risk modeling techniques that are of particular relevance to actuarial work, including survival models and their application.

**Objectives of this course**
On successful completion of this course, a student will be able to:

- describe the essential features of statistical distribution
- use statistical distributions for risk modeling
- describe and apply techniques of survival analysis
- describe and apply the basic principles of machine learning

**Learning Outcomes of this course**
At the end of the course, the students will be able to

- know what is the appropriate statistical distributions for risk modeling
- know the interpretation the result of the risk model

**Course Content**

**Introduction:** Basic concept of Actuarial Science, Relationship with life insurance, Uses of Actuarial Statistics in context of Bangladesh.

**Economic Insurance**: Utility theory, application of probability to problem of life and death. Determination of single premium for insurances and annuities in both discrete and continuous cases. Theory and practice of pension plan funding assumptions, basic actuarial function, Population theory applied to private pensions.

**Copula:** Copula and Random Variables and properties, Families of copula, Sklar's Theorem, Fréchet-Hoeffding Bounds for Joint Distribution, Survival Copula, Multivariate Copulas, Methods of Constructing Copulas, Algebraic Methods, Archimedean Copulas, Dependence, Quadrant Dependence and Properties, Concordance, Concordance function, Quasi-copulas, Multivariate copulas, Measures Based on Gini's Coefficient, Distributions with Fixed Margins.

**Distribution of Risk Modeling:** Loss distribution with and without risk sharing, Compound distribution and their applications in the risk modeling.

**Survival Model:** Explain the concepts of survival model, Describe estimation procedure for lifetime distribution, Derive maximum likelihood estimators for transition intensities, estimate transition intensities dependent on age (exact or census), valuation theory for pension plans, expense function and dividends.

**Machine Learning:** Definition, Types of machine learning, principles, supervised and unsupervised techniques, one and multi class classification.

**Information Theory**: Entropy, KL divergence, Mutual information, high level concept relevant to learning from data, appropriate software concept.

**Main Books Recommended:**


Nelsen, Roger B. (2006). An Introduction to Copulas, 2nd ed., Springer Science+Business Media, Inc.

Murphy, Kevin P. (2012). Machine Learning: A Probabilistic Perspective, The MIT Press, Cambridge, Massachusetts, London, England.

Parmenter, M. M. (1988). Theory of interest and life contingencies with pension and application, ACTEX publication, Winsted, CT, USA.

Rejda, George, E. (2008). Principles of Risk management and Insurance, Pearson Education, Inc.


**References**


Genest, C. and Rivest, L.-P., (1993). Statistical inference procedures for bivariate Archimedean copulas. J. Amer. Statist. Assoc. 55, 698-707.

Nelsen, R. B. (1999). An Introduction to Copulas. Springer, New York.

Borowiak, Dale S. (2003). Financial and Actuarial Statistics: An Introduction, University of Akron, Akron, Ohio, U.S.A.

Bowers, N. L. Gerber, H. V., Hickman, J.C., Jones, D. A. and Nesbit, C. J. (1978). Actuarial Mathematics, Society of Actuaries, Chicago.

Olivieri, Annamaria; · Ermanno Pitacco (2011). Introduction to Insurance Mathematics: Technical and Financial Features of Risk Transfers, Springer-Verlag Berlin Heidelberg.

Molak, Vlasta (1997). Risk Analysis and Risk Management, CRC Press, Inc.

Cížek, Pavel; Wolfgang ärdle; RafałWeron (2011). Statistical Tools for Finance and Insurance, Springer-Verlag Berlin Heidelberg.

Perna, Cira; Marilena Sibillo (2008). Mathematical and Statistical Methods in Insurance and Finance, Springer-Verlag Italia, Milano.


## B. Stat. - 410
## Practical
## Full Marks - 200

(70% for Practical Exam. and 30% for continuous Lab assessment)

**(Seven sessions, each of Five hours durations)**

**Session-I: Multivariate Analysis (Related to B. Stat.- 401) (Marks 30)**

1. Test for a mean vector.
2. Test for equality of Mean vectors.
3. Classification of Multivariate observations into K normal populations with unspecified parameters.
4. Principal component analysis of multivariate data and verification of properties of the Principal Components.
5. Factor Analysis of Multivariate data including Factor Rotation, Factor interpretation etc.
6. Estimation and interpretation of canonical varieties and canonical correlation.

7. Application of computer package programs for multivariate Data Analysis

**Session-II**: **Demography (Related to B. Stat.- 402) (Marks 30)**

1. Presentation of Population and Demographic Data by Graphs and Charts.
2. Computations of Population Change and Growth rates.
3. Analysis of Age and Sex Data. Computation of Aging Indices.
4. Evaluation of Age and Sex Data by Whipple's, Myer's and UN Age Sex Accuracy Indices.
5. Analysis of Marital status Distribution. Marriage and Divorce Rates.
6. Computation of different Measures of Fertility and Reproduction from vital registration and census data (such as CWR, CBR, ASFR, ASMFR, TFR, GFR, GRR, NRR and PPR).
7. Computation of Different measures of Mortality CDR, ASMR, IMR, Neonatal, Perinatal death rates.
8. Standardization of Birth, Death, Marriage and Divorce Rates.
9. Construction of Complete and Abridged life Tables, by different Methods.
10. Computation of Migration Rates. Estimates of migration by survival methods.
11. Population Estimates and Projection using Mathematical Methods.

**Session-III**: **Biostatistics and Bioinformatics (Related to B. Stat.- 403) (Marks 30)**

1. Non-parametric Estimation of survival probabilities and their Standard errors from ungrouped and grouped data.
2. Construction of survival curves and their confidence belts.
3. Graduation of life data (Censored and uncensored) by plotting procedures.
4. Fitting of appropriate parametric model (one parameter exponential, two parameter exponential and Weibull) to observed data and testing goodness of fit of fitted models (Kolmogrov- Smirnov test, L.R. test)
5. Construction of confidence limits for life parameters for the fitted models.
6. Computations of attributable and relative Risks - odds Ratio Analysis with standard Errors and confidence Interval of odds Ratios.
7. Linkage Analysis and Map Construction for both backcross (B1 & B2) and inter-cross (F2) population. Analysis of recombination fraction.
8. DNA sequence data Analysis by statistical phylogenetics approaches.
9. Detection of differentially expressed (DE) genes by classical, Bayesian and non-parametric approaches.
10. Detection of differentially co-expressed (DCE) genes by classical, Bayesian and non-parametric approaches.

**Session-IV**: **Economic Statistics and Econometrics (Related to B. Stat.- 404) (Marks 30)**

1. Fitting Engel Functions to Family Budget Data.
2. Estimation of Aggregate Demand function from Time Series Data.
3. Fitting Pareto's Law and Lognormal Distribution to Personal Incomes.
4. Determination of Concentration Ratio from Lorenz Diagram.
5. Fitting of CD Production Function and CES Production Functions.
6. Analysis of Time Series Data: Test of Randomness.

7. Determination of Trend, Seasonal and Cyclical Components. Forecasting and Prediction.
8. Solution of the problems using Computer programs and packages.

**Session-V**: **Actuarial Statistics (Related to B. Stat.- 409) (Marks 30)**

1) **A**pplication of probability to solve the problems of life and death.
2) Determination of single premium for insurances and annuities in both discrete and continuous case.
3) Application of Life Insurance and Life Annuities
4) Determination of Survival Copulas, Multivariate Copulas, Archimedean Copulas, Loss distribution with and without risk sharing, lifetime distribution, pension plans, expense function and dividends.
5) Application of supervised and unsupervised Learning.
6) Measurement of Entropy and Negentrophy.

**Session–VI**: **Operations Research and Quality Control (Related to B. Stat.- 405) (Marks 25)**

1. Solution of Linear Programming Problems by Simplex Method and Revised Simplex Method.
2. Dual Simplex Algorithm, Solution of Integer Programming Problems.
3. Solution of Transportation problems through Linear Programming Method.
4. Graphical Solution of (2 × 2), (2 × n) and (m × 2) Games and Solution of (m x n) Games by Simplex Method.
5. Construction of Variable control charts and attribute control charts.
6. Estimation of OC, ASN and AOQ for single and Double Sampling Plans and to find the AOQL for the plans.
7. Determination of the Sampling plans for given values of fraction defective.
8. Solution using Computer program and Statistical Packages.

**Session-VII: Statistics for Sustainable Development Goals (Related to B. Stat.- 408) (Marks 25)**

1) Make a list of SDGs
2) Make a graphical view of the Indicators for SDGs.
3) Make a graphical view of International aid and technological progress.
4) Identify the data gap within goals, targets and indicators of SDGs.
5) Make a Recommendation for the fulfillment of the above Gap.

**B. Stat.- 411**
**Research Project**
**Full Marks- 50**

**B. Stat.- 412**
**Viva Voce and Presentation**
**Full Marks- 100**