

# Curriculum

Undergraduate  
Session: 2021-2022

## Syllabus

Graduate  
Session: 2021-2022

# Department of Statistics



Shahjalal University of Science and Technology  
Sylhet, Bangladesh

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## FACULTY LIST (Current)

## Ordinance for Semester System for Bachelor's Degree

| Sl No. | Full Name                     |                            |
|--------|-------------------------------|----------------------------|
|        | Professor & Head              |                            |
| 1.     | Professor Dr. Rahmat Ali      | 01778266418<br>01552438862 |
|        | Professors                    |                            |
| 2.     | Dr. Md. Kabir Hossain         | 01711184818                |
| 3.     | Dr. Md. Zakir Hossain         | 01711140801                |
| 4.     | Dr. Sabina Islam              | 01911720525                |
| 5.     | Dr. Ahmad Kabir               | 01711116908                |
| 6.     | Mr. Md. Ahmed Kabir Chowdhury | 01714227456                |
| 7.     | Dr. Md. Azizul Baten          | 01716262947                |
| 8.     | Dr. Mohammed Taj Uddin        | 01716348194                |
| 9.     | Dr. Mohammad Shahidul Islam   | 01777827876                |
| 10.    | Dr. Md. Nazrul Islam          | 01711466280                |
| 11.    | Dr. Mohammad Ohid Ullah       | 01818101435                |
| 12.    | Dr. S. M. Khurshid Alam       | 01716090465                |
| 13.    | Dr. Khalidur Rahman           | 01712068785                |
| 14.    | Dr. Md. Jamal Uddin           | 01716972846                |
| 15.    | Dr. Luthful Alahi Kawsar      | 01711318223                |
|        | Associate Professors          |                            |
| 16.    | Mr. Mohammad Romel Bhuia      | 01782728082                |
| 17.    | Dr. Mossamet Kamrun Nesa*     | 01796747485                |
| 18.    | Dr. Mirza Nazmul Hasan        | 01767013458                |
| 19.    | Dr. Kanis Fatama Ferdushi*    | 01818824338                |
|        | Assistant Professors          |                            |
| 20.    | Mr. Mirajul Islam             | 01675018522                |
| 21.    | Mr. Sabbir Tahmidur Rahman*   | 01717340857                |
| 22.    | Mrs. Nahid Sultana*           | 01728707307                |

(This ordinance will replace other ordinances/resolutions etc. on the issues described here; however, it will not affect ordinances/resolutions on issues not mentioned here.)

### 1. Student Admission

#### 1.1 Undergraduate Admission:

The admission committee of the university will conduct the admission process for Bachelor's degree as per the rules. The student will be admitted in the first semester of an academic year in the individual discipline of different schools. However the admission of foreign students will be subjected to the verification of academic records as per the university rule.

#### 1.2 Student Status and Student Level:

Every student has to maintain his/her student status by getting admission paying necessary fees and register for required credits every semester. Unless a student graduate early by taking courses in advance, every student has to get admission in every semester successively. For book keeping purpose a student's level will be expressed by his/her year and semester. A student will be transferred to next level if he/she completes or appears in 80% of his designated courses at his/her present level. Once a student reaches 4th year 2nd (5th year 2nd for Architecture) semester he/she will be kept at this level until he/she graduates.

#### 1.3 Re-Admission:

A student has to take re-admission if his/her student status is not maintained or one or more semesters were cancelled because of disciplinary action against him/her. In case of semester cancellation the student has to get re-admission in the same semester. The level (Year and Semester) of re-admission will be determined by his completed/appeared credits. A student will be eligible for re-admission in the first year first semester of the subsequent session if he/she was present in at least 25% of the classes of his/her major courses and his/her admission/semester fees was clear in the past semester/session. Re-admitted students will always be assigned the original Registration Number.

#### 1.4 Student's Advisor:

After admission every batch of student will be assigned to a student's Advisor from the teacher of his/her discipline to guide him/her through the semester system. Advisors will always be accessible to the students and will be ready to mentor them in their academic activities, career planning and if necessary, personal issues. There will be a prescribed guideline for the Advisors to follow.

### 2. Academic Calendar

#### 2.1 Number of Semesters:

There will be two semesters in an academic year. The first semester will start on 1st January and end on 30th June, the Second semester will start on 1st July and end on 31st December. The routine of the final examination dates along with other

academic deadlines will be announced in the academic calendar at the beginning of each semester.

## 2.2 Duration of Semesters:

The duration of each semester will be as follows:

|                               |          |
|-------------------------------|----------|
| Classes and Preparatory weeks | 15 weeks |
| Final Examination             | 04 weeks |
| Total                         | 19 weeks |

These 19 weeks may not be contiguous to accommodate various holidays and the Recess before the final examination may coincide with holidays. The final grading will be completed before the beginning of the next semester.

## 3. Course Pattern

The entire Bachelor's degree program is covered through a set of theoretical, practical, project, viva and seminar courses. At the beginning of every academic session a short description of every available course will be published by the syllabus committee of each discipline.

### 3.1 Course Development:

#### 3.1.1 Major and Non-Major Courses:

Syllabus committee of every discipline will develop all the courses that will be offered by that particular discipline and has to be approved by the respective school and the Academic Council. These include major courses for the respective discipline as well as non-major courses that will be offered to other disciplines. Non-major courses will be developed with close cooperation of the disciplines concerned keeping into consideration of the need of that discipline.

#### 3.1.2 Syllabus:

(a) Major and Non-Major Courses: Syllabus committee will select and approve the courses from major courses of the discipline as well as non-major courses offered by other disciplines to complete the syllabus. The syllabus committee will also select a group of courses as core-courses and without these courses a student will not be allowed to graduate even if he completes the credit requirement. The committee may assign pre-requisite for any course if deemed necessary.

(b) Second Major Courses: The syllabus committee will select a set of courses of 28-36 credits from the major courses for a second major degree.

#### 3.1.3 Course Instruction:

At the beginning of every semester the course instructor has to make a detailed plan of the course instruction in the prescribed form and supply it to the head of the discipline to make it available to the students. The course plan should have the information about the suggested text books, number of lectures per topic, number and type of assignments, number and approximate dates of mid-semester examinations and mandatory office hours reserved for the students of the course offered. If not otherwise mentioned the medium of instruction is always English.

### 3.2 Course Identification System:

Each course is designated by a three-letter symbol for discipline abbreviation followed by a three-digit number to characterize the course. To avoid confusion new or modified courses should never be identified by reusing a discontinued course number.

#### 3.2.1 Discipline Identification:

The three-letter symbol will identify a discipline offering the course as follows. If same course is offered to more than one discipline, if necessary, an extra letter shown in the list may be used after the three digits to specify the department receiving the non-major course.

|     |     | <b>School of Applied Sciences and Technology:</b>        |   |
|-----|-----|----------------------------------------------------------|---|
| 1.  | ARC | Architecture                                             | A |
| 2.  | CEP | Chemical Engineering and Polymer Science                 | B |
| 3.  | CEE | Civil and Environmental Engineering                      | C |
| 4.  | CSE | Computer Science and Engineering                         | D |
| 5.  | EEE | Electrical and Electronic Engineering                    | E |
| 6.  | FET | Food Engineering and Tea Technology                      | F |
| 7.  | IPE | Industrial and Production Engineering                    | G |
| 8.  | MEE | Mechanical Engineering                                   | Q |
| 9.  | PME | Petroleum and Mining Engineering                         | H |
|     |     | <b>School of Life Sciences:</b>                          |   |
| 10. | BMB | Biochemistry and Molecular Biology                       | I |
| 11. | GEB | Genetic Engineering and Biotechnology                    | J |
|     |     | <b>School of Physical Sciences:</b>                      |   |
| 12. | CHE | Chemistry                                                | K |
| 13. | GEE | Geography and Environment                                | L |
| 14. | MAT | Mathematics                                              | M |
| 15. | OCG | Oceanography                                             | S |
| 16. | PHY | Physics                                                  | N |
| 17. | STA | Statistics                                               | O |
|     |     | <b>School of Social Sciences:</b>                        |   |
| 18. | ANP | Anthropology                                             | a |
| 19. | BNG | Bangla                                                   | b |
| 20. | ECO | Economics                                                | c |
| 21. | ENG | English                                                  | d |
| 22. | PSS | Political Studies                                        | e |
| 23. | PAD | Public Administration                                    | f |
| 24. | SCW | Social Work                                              | g |
| 25. | SOC | Sociology                                                | h |
|     |     | <b>School of Agriculture and Mineral Sciences:</b>       |   |
| 26. | FES | Forestry and Environmental Science                       | P |
|     |     | <b>School of Management and Business Administration:</b> |   |

|     |     |                                                               |   |
|-----|-----|---------------------------------------------------------------|---|
| 27. | BUS | Business Administration                                       | i |
|     |     | <b>Institute of Information and Communication Technology:</b> |   |
| 28. | SWE | Software Engineering                                          | W |

### 3.2.2 Course Number:

The three-digit number will be used as follows:

- (a) First Digit: The first digit of the three digit number will correspond to the year intended for the course recipient.
- (b) Second Digit: A discipline should use the number 0 and 1 for the second digit to identify non-major courses. The digits 2-9 are reserved for major courses to identify the different areas within a discipline.
- (c) Third Digit: The third digit will be used to identify a course within a particular discipline. This digit can be used sequentially to indicate follow up courses. If possible even numbers will be used to identify laboratory courses.

### 3.2.3 Course Title and Credit:

Every course will have a short representative course title, declaration if it is core course, a number indicating the total credits as well as reference to prerequisite courses if any.

### 3.2.4 Theory and Lab Course:

If a single course has both Theory and Laboratory/Sessional part, then the course must be split into separate Theory and Lab courses and both should have separate course number. A student may not register for a lab course without registering or completing the corresponding theory course.

## 3.3 Assignment of Credits:

### 3.3.1 Theoretical:

One lecture per week (or 13 lectures in total) of 1 hour duration per semester will be considered as one credit. (There will be 10 minutes recess between theory classes). A theory course will have only integer number of credits.

### 3.3.2 Laboratory Classes:

Minimum two contact hours of a laboratory class per week (or 26 contact hours in total) per semester will be considered as one credit. A laboratory course may have half integer credits with a minimum of 1 credit.

### 3.3.3 Seminar, Thesis, Projects, Monographs, Fieldwork, Viva etc.:

Will be assigned by the respective discipline.

## 3.4 Classification of the Courses:

The Bachelor's degree courses will be classified into several groups and the syllabus committee will finalize the curricula selecting courses from the groups shown below.

### 3.4.1 Major Courses:

A student has to take at least 70% courses from his/her own discipline. Out of these courses a section will be identified as core courses and every student of a particular discipline will be required to take those courses.

### 3.4.2 Non-Major Courses:

Every student is required to take at least 20% (including mandatory) courses from related disciplines. If any Non-Major course is declared as Core course a student is required to take that course to graduate. The Non-Major courses will be designed, offered and graded by the offering disciplines.

### 3.4.3 Other Courses:

After completion of the required mandatory, major and non-major courses a student may take few other courses of his/her choice not directly related to his/her discipline to fulfill the total credit requirement.

### 3.4.4 Credit-Only Courses:

The credit of these Credit-Only courses will be added to the total credits if passed but will not affect the CGPA as there will be no grades for these courses.

## 4. Course Registration

### 4.1 Registration:

A student has to register for his/her courses and pay necessary dues within the first two weeks of every semester. Departmental student advisor will advise every student about his/her courses and monitor his/her performances. A student at any level is expected to register the courses at his level provided he/she does not have any incomplete courses from previous levels. A student will not be allowed to appear in the examination if his/her semester and examination fee is not cleared.

### 4.2 Minimum and Maximum Credits:

A student, if s/he is not a clearing graduate, has to register for at least 12 credits minimum and 30 credits maximum every semester.

### 4.3 Incomplete Courses:

If a student has incomplete courses, he/she has to register his/her available incomplete courses from preceding levels before s/he can register courses from current or successive levels. If an incomplete course is not offered in a given semester the student has to take the courses when it is offered next time. A student will not be allowed to take 100 and 300 level and 200 and 400 level courses simultaneously. 100 level courses mean courses of 1st and 2nd semesters, 200 level courses mean courses of 3rd and 4th semesters and so on. A student with incomplete courses will not be eligible for Distinction.

### 4.4 Course Withdrawal:

A student can withdraw a course by a written application to the Controller of Examinations through the Head of the discipline on or before the last day of instruction. The Controller of Examinations will send the revised registration list to

the disciplines before the examination. There will be no record of the course in transcript if the course is withdrawn.

#### 4.5 Course Repetition:

If a student has to repeat a failed or incomplete course and that course is not offered any more, the discipline may allow him/her to take an equivalent course from the current syllabus. For clearing graduates if any incomplete course is not offered in the running semester, the discipline may suggest a suitable course to complete the credit requirement.

### 5. Graduation Criteria

#### 5.1 Major Degree:

##### 5.1.1 Total Credits:

School of Physical Sciences, School of Social Sciences and School of Management and Business Administration have a requirement of 140 credits to graduate from its disciplines. School of Applied Sciences and Technology, School of Life Sciences and School of Agriculture and Mineral Science have requirement of 160 (200 for Architecture) credits for graduation.

##### 5.1.2 Total Years:

A regular student is expected to graduate in 8 semesters (4 years) or in 10 semesters (5 years) for the discipline of Architecture. A student may graduate in shorter time period if s/he is willing to take extra courses in a systematic way. A student will be given 4 (2 years) extra semesters in addition to 8/10 semesters to complete his/her degree. The regular examination year will be identified by the session and the end-month (June or December) of the semester the student graduates.

##### 5.1.3 Minimum Credit for a Clearing Graduate:

For a clearing graduate (8th and subsequent semesters) condition for maximum and minimum credit requirements is relaxed.

##### 5.1.4 Break in study:

In very special cases, a student may take re-admission and complete his degree after a break of study of a minimum of one to a maximum of three years if he/she has completed at least 80% of required courses. He/she has to have recommendations from the discipline, and the application has to be approved by the Academic Council. These students will not get any additional time benefit.

#### 5.2 Second Major Degree:

##### 5.2.1 Total Credits:

A student may apply for a second major degree if he/she completes an extra 28-36 credit requirement designated by the offering discipline.

##### 5.2.2 Total Semesters:

A student has to complete the credit requirement of second major degree within 8 regular and 4 extra semesters.

##### 5.2.3 Requirement of Major Degree:

A student will not be given a second major degree if he/she fails to complete his regular major degree. A student will not be allowed to enroll in Masters program

before completion of his/her second major degree even if he/she complete his/her major degree requirement.

#### 5.2.4 Registration Criteria:

An offering discipline will decide on the number of seats for second major, enrollment criteria and get it approved from the academic council. Students willing to get a second major have to apply to the offering discipline for enrollment and the discipline will enroll them as per the admission criteria. During registration enrolled students have to get their courses approved from the offering department completing a separate registration form.

#### 5.2.5 Class Routine:

After enrollment a regular student may start taking the second major courses starting 3rd semester. The class routine may be arranged to accommodate the student need.

#### 5.2.6 Certificate and Mark sheet:

A student completing the requirement will be given an additional certificate and grade sheet for his second major degree.

### 6. Examination System

A student will be evaluated continuously in the courses system, for theoretical classes s/he will be assessed by class participation, assignments, quizzes, mid-semester examinations and final examination. For laboratory work s/he will be assessed by observation of the student at work, viva-voce during laboratory works, from his/her written reports and grades of examinations designed by the respective course teacher and the examination committee.

#### 6.1 Distribution of Marks:

The marks of a given course will be as follows:

|                                             |     |
|---------------------------------------------|-----|
| Class Attendance                            | 10% |
| Mid-Semester Examinations                   | 20% |
| Assignments/Evaluation/Class Test/Quiz Test | 10% |
| Final Examination                           | 60% |

##### 6.1.1 Class Participation:

The marks for class participation will be as follows:

| Attendance (Percentage) | Marks | Attendance (Percentage) | Marks | Attendance (Percentage) | Marks |
|-------------------------|-------|-------------------------|-------|-------------------------|-------|
| 95 and above            | 10    | 80 to 84                | 7     | 65 to 69                | 4     |
| 90 to 94                | 9     | 75 to 79                | 6     | 60 to 64                | 3     |
| 85 to 89                | 8     | 70 to 74                | 5     | Less than 60            | 0     |

A student will not be allowed to appear at the examination of a course if his/her class attendance in that course is less than 50%.

### 6.1.2 Assignments and Mid-Semester Examinations:

There should be at least two mid-semester examinations for every course. The course teacher may decide the relative marks distribution between the assignments, tutorial and mid-semester examinations, however at least 50% contribution should come from the mid-semester examinations. The answer script should be returned to the students as it is valuable to their learning process.

### 6.1.3 Final Examination:

The final examination will be conducted as per the Semester Examination Ordinance.

(a) Duration of the Final Examination: There will be a 3-hour final examination for every course of 3 credits or more after the 13th week from the beginning of the semester. Courses less than 3 credits will have final examination of duration 2 hours.

(b) Evaluation of Answer Script: The students of the School of Applied Science and Technology and the School of Agriculture and Mineral Sciences will have two answer scripts to answer separate questions during final examination. Two separate examiner will grade the two scripts separately and the marks will be added together to get the final mark. For the students of the other schools there will be a single answer script which will be evaluated by two examiners. The two marks will be averaged and if the marks by the two examiners differ by 20% or more the concerned answer scripts will be examined by a third examiner and the two closest marks among the three will be averaged to get the final mark.

## 7. Grading System

### 7.1 Letter Grade and Grade Point:

Letter Grade and corresponding Grade-Point for a course will be awarded from the roundup marks of individual courses as follows:

| Numerical Grade      | Letter Grade | Grade Point |
|----------------------|--------------|-------------|
| 80% and above        | A+           | 4.00        |
| 75% to less than 80% | A            | 3.75        |
| 70% to less than 75% | A-           | 3.50        |
| 65% to less than 70% | B+           | 3.25        |
| 60% to less than 65% | B            | 3.00        |
| 55% to less than 60% | B-           | 2.75        |
| 50% to less than 55% | C+           | 2.50        |
| 45% to less than 50% | C            | 2.25        |
| 40% to less than 45% | C-           | 2.00        |
| Less than 40%        | F            | 0.00        |

## 7.2 Calculation of Grades

### 7.2.1 GPA:

Grade Point Average (GPA) is the weighted average of the grade points obtained in all the courses completed by a student in a semester.

### 7.2.2 CGPA:

Cumulative Grade Point Average (CGPA) of only major and both major and second major degree will be calculated by the weighted average of every course of previous semesters along with the present semester. For clearing graduates if the roundup value of the third digit after decimal is nonzero the second digit will be incremented by one. A student will also receive a separate CGPA for his second major courses.

### 7.2.3 F Grades:

A student is given an 'F' grade if he fails or is absent in the final examination of a course. If a student obtains an 'F' grade his grade will not be counted for GPA and s/he has to repeat the course. An 'F' grade will be in his/her record and s/he will not be eligible for Distinction.

## 8. Distinction

### 8.1 Distinction:

Candidates for four-year Bachelor's degree will be awarded the degree with Distinction if his/her overall CGPA is 3.75 or above. However, a student will not be considered for Distinction if (a) s/he is not a regular student (has semester drop, incomplete courses in any semester or break of study) (b) has 'F' grade in one or more courses.

Ref.: This Ordinance was approved in the 126th Academic Council (26 June 2013). Clause 3.4.1 was cancelled in 127th Academic Council (27 August 2013). 128th Academic Council (21 November 2013) decided to make it effective from 01 January 2014. Clause 6.1 of 126th Academic Council (13 December 2018) and decided to be effective it from the academic session (2018-2019). Clause 1.3 was revised in 155th Academic Council (17 April 2019).

|                                                        |                    |                      |                             |
|--------------------------------------------------------|--------------------|----------------------|-----------------------------|
| <b>Course Code: MSC004</b>                             | <b>Credits: 03</b> | <b>Semester: 4-2</b> | <b>Year: 4<sup>th</sup></b> |
| <b>Course Title: Military Science</b> (সামরিক বিজ্ঞান) |                    |                      |                             |

**Rationale/যৌক্তিকতা :** বাংলাদেশ ন্যাশনাল ক্যাডেট কোর বি এন সি সি এর সুদীর্ঘ ঐতিহ্যের ইতিহাস রয়েছে। ১৯২৩ সালে ইন্ডিয়ান টেরিটোরিয়াল ফোর্স (ITF) এ্যান্ট পাশ হবার পর অস্ত্রাধারি টেরিটোরিয়াল ফোর্সেস কমিটির সুপারিশক্রমে ঢাকাতে একটি ইউনিভার্সিটি ট্রেনিং কোর (UTC) গঠন করা হয় এবং এর মধ্য দিয়ে ক্যাডেট কোরের যাত্রা শুরু হয়। জ্ঞান, শৃঙ্খলা ও একতা এই তিন মূল মন্ত্রে উদ্ভূত করে দেশের যুব সমাজ তথা স্কুল, কলেজ ও বিশ্ববিদ্যালয়ের ছাত্রছাত্রীদের লেখাপড়ার পাশাপাশি সামরিক প্রশিক্ষণের মাধ্যমে দ্বিতীয় সারির প্রতিরক্ষা বাহিনী হিসেবে গড়ে তোলা এবং নৈতিক চরিত্র বিকাশ এই কোর্সের লক্ষ্য।

**Course Objectives/লক্ষ্য ও উদ্দেশ্য:** এই কোর্সটি পাঠ্যসূচিতে অঙ্গভুক্ত করার উদ্দেশ্য হল- দেশের কাজে ত্যাগের মনোভাব এবং শিক্ষার্থীদের মধ্যে ভ্রাতৃত্ববোধ গড়ে উঠবে। শিক্ষার্থীদের নৈতিক চরিত্রের উন্নতি সাধন করবে। দেশের প্রতিরক্ষা কাজে উৎসাহ ও উদ্দীপনা যোগাবে। জাতীয় উন্নয়নমূলক কর্মকাণ্ডে ও দুর্যোগের সময় সৃশৃঙ্খল স্বেচ্ছাসেবক বাহিনী হিসেবে গড়ে তুলবে। বহিঃশত্রুর আক্রমণের প্রেক্ষিতে দ্বিতীয় সারির প্রতিরোধ বাহিনী হিসেবে গড়ে তুলবে।

#### Course Learning Outcomes(CLOs)/ফলাফল :

এই কোর্সটি অধ্যয়নের ফলে শিক্ষার্থীরা যে সকল বিষয়ে সম্যক জ্ঞান ও দক্ষতা অর্জন করবে-

CLO-1: ব্যক্তিস্বার্থ, হীনমন্যতা, রাজনীতি ও নৈতিক পদস্থলন থেকে মুক্ত থাকবে।

CLO -2: রাষ্ট্রীয় পর্যায়ে বিভিন্ন কর্মকাণ্ডে নিরাপত্তা বাহিনীকে সহায়তা প্রদান করতে পারবে।

CLO -3: দেশপ্রেমিক ও মানবতাবাদী সুন্দর ও ভালো মনের মানুষ হিসেবে গড়ে তুলতে সাহায্য করবে।

CLO -4: আত্মবিশ্বাসে বলীয়ান হয়ে উঠবে।

CLO -5: সুশৃঙ্খল ও আনুগত্যশীল যুব সমাজ তৈরি করবে।

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | ✓        | ✓        |          | ✓        |          | ✓        |          |          | ✓        |           |
| CLO2        |          | ✓        | ✓        | ✓        | ✓        | ✓        |          | ✓        | ✓        | ✓         |
| CLO3        | ✓        | ✓        |          |          | ✓        |          | ✓        | ✓        |          | ✓         |
| CLO4        | ✓        |          | ✓        | ✓        | ✓        | ✓        | ✓        |          | ✓        |           |
| CLO5        | ✓        | ✓        |          |          | ✓        |          |          | ✓        | ✓        | ✓         |

#### Course Contents/পাঠ্যক্রম :

পঠিত বিষয় (তত্ত্বীয় ও ব্যবহারিক) : বি এন সি সি'র ইতিহাস-ঐতিহ্য, বি এন সি সি'র সাংগঠনিক কাঠামো, মহান স্বাধীনতা যুদ্ধের পটভূমি ও কারণ, স্বাধীনতা যুদ্ধের সেক্টর সমূহ, ড্রিল, কুচকাওয়াজ, ম্যাপ রিডিং, যুদ্ধের নানা কৌশল, যুদ্ধে ব্যবহৃত অস্ত্রের পরিচয়, বাংলাদেশের সশস্ত্র বাহিনীর পরিচয়, নেতৃত্বের বৈশিষ্ট্য, শরীর চর্চা, প্রাথমিক চিকিৎসা, সমাজ সেবা, দুর্যোগ ব্যবস্থাপনা, ভূমিকম্প ব্যবস্থাপনা, ঘূর্ণিঝড় ব্যবস্থাপনা, অগ্নি নির্বাপনের কৌশল, সাংস্কৃতিক প্রশিক্ষণ ইত্যাদি।

#### Recommended Books/সহায়ক গ্রন্থ :

বি এন সি সি : সামরিক বিজ্ঞান সদর দপ্তর কর্তৃক নির্ধারিত ও প্রকাশিত।

Department of Statistics  
School of Physical Sciences  
Shahjalal University of Science and Technology  
Sylhet – 3114, Bangladesh

#### Course Curriculum for B.Sc. (Honours) Program Session: 2021-2022

#### Overview

Shahjalal University of Science and Technology (SUST) is the first science and technology university in Bangladesh and many of its departments are at the national and international forefront of education and research in various fields. The Department of Statistics at SUST, which began its academic journey in 1991, is one of the pioneer departments of the university. It is one of the largest concentrations of statistical education and research with 24 faculties and 366 undergraduate and graduate students. Among the faculty members, there are 15 Professors, 4 Associate Professors and 5 Assistant Professors. Along with a wide range of contemporary and demand-driven courses in undergraduate and graduate levels, the department also offers MPhil and PhD programs. The department has already produced 4 PhD, 1 MPhil, 600 MS graduates, and 785 B.Sc. (Honours) graduates. Every year average number of intakes in undergraduate level is 80 and 30 in graduate program. Currently 5 PhD and 4 MPhil students are pursuing research in the department towards achieving their goals. The department has two computer laboratories equipped with more than 140 computers under complete network coverage and internet facility. Students enjoy working with state of the art statistical and other related software. We have a well-organized seminar library with sufficient books, journals, periodicals and other publications. Our faculties and students are regularly publishing their research works in scientific peer reviewed national and international journals and in book chapters. The Department has an association, named 'Parishankhyan Paribar', which is the central banner for organizing all extra-curricular activities of the department, such as cultural programs, games and sports, picnic etc. The department has formed Statistical Alumni Association for the greater interest of the graduates. This department received grants from many projects, most notably two Higher Education Quality Enhancement Project (HEQEP) – one in collaboration with the Department of Mathematics and the other by the entity itself for infrastructural development. The Department of Statistics regularly organizes seminars and workshops on contemporary research issues which helps faculty members become updated on cutting-edge topics by sharing knowledge and views, and make students acquaint with research in the subject.

Employment opportunities for our graduates are excellent. Our students find careers in research organizations, diverse government sectors, public and private universities, commercial banks and financial institutions, central bank (Bangladesh Bank), insurance companies, UN associate organizations, national and international NGOs, reputed national and multinational companies, and other academic institutions in home and abroad. Moreover, every year a notable number of students get admission to reputed foreign universities for higher studies with financial supports.

**Vision**

Evolving expertise in statistics to serve nationally and internationally

**Mission**

- M1** - Achieve excellence and expansion of knowledge in Statistics as well as in data science  
**M2** - Promote and tailor research to ensure sustainable development of the country  
**M3** - Maintain the quality of teaching and research at international standard  
**M4** - Collaborate with stakeholders for planning, statistical analysis and research  
**M5** - Advise government to take appropriate decision for achieving development goals

**Program Education Objectives (PEO)**

- PEO1** - To provide in-depth knowledge of descriptive and inferential statistics  
**PEO2** - To promote creative thinking, so that graduates become able to explore and analyze different kinds of data produced from various disciplines  
**PEO3** - To boost up a spirit of enquiry, so that graduates search for facts and truths by developing statistical tools that supports critical analysis and decision making  
**PEO4** - To help students comprehend the roles of statistics in science and engineering especially industrial, environmental, social, biomedical, epidemiological, agricultural, biological and economical aspects nationally as well as internationally  
**PEO5** - To acquaint students with a spirit of ethics and social commitment in the personal and professional life of graduates so that they add value to the society in national and international levels

**PEO to Mission Statement Mapping**

|    | PEO1 | PEO2 | PEO3 | PEO4 | PEO5 |
|----|------|------|------|------|------|
| M1 | 3    | 3    | 3    | 3    | 2    |
| M2 | 3    | 3    | 2    | 3    | 3    |
| M3 | 3    | 3    | 3    | 2    | 2    |
| M4 | 2    | 2    | 3    | 3    | 2    |
| M5 | 3    | 2    | 3    | 2    | 2    |

Matching Level: 1=Low, 2=Medium, 3=High

**Program Learning Outcomes (PLO)**

- PLO1** Explain acquired knowledge of statistical theories and practices along with other allied subjects such as Mathematics, Economics, Computer Science, English and History of Emergence of Independent Bangladesh  
**PLO2** Prepare design and implement it for collecting data from observational and experimental studies  
**PLO3** Analyze data from various disciplines, represent and interpret the results to respective stakeholders  
**PLO4** Demonstrate critical thinking and analytical abilities to make data-driven decisions  
**PLO5** Collaborate with members in multi-disciplinary groups  
**PLO6** Analyze big data and employ Big Data Technology  
**PLO7** Capable of conducting research independently

- PLO8** Demonstrate in depth knowledge of statistics embedded with ethics and sense of social commitment and to strive towards personal development and value creation to society  
**PLO9** Effectively communicate, both verbal and written, with co-workers, higher authorities, stakeholders, and general audience  
**PLO10** Devise a way on the road to future career

**Program Objectives (PEO/PO) to Program Learning Outcomes (PLO) Mapping**

| PLO/PEO | PEO1 | PEO2 | PEO3 | PEO4 | PEO5 |
|---------|------|------|------|------|------|
| PLO1    | 3    | 3    | 3    | 3    | 1    |
| PLO2    | 3    | 3    | 3    | 3    | 3    |
| PLO3    | 3    | 2    | 2    | 2    | 2    |
| PLO4    | 2    | 3    | 2    | 3    | 2    |
| PLO5    | 2    | 1    | 3    | 3    | 2    |
| PLO6    | 3    | 2    | 3    | 2    | 1    |
| PLO7    | 3    | 3    | 3    | 3    | 3    |
| PLO8    | 2    | 2    | 2    | 3    | 3    |
| PLO9    | 1    | 2    | 2    | 3    | 3    |
| PLO10   | 1    | 2    | 2    | 3    | 3    |

Matching Level: 1=Low, 2=Medium, 3=High

**Grading System**

| Numerical Grade      | Letter Grade |             | Grade Point |
|----------------------|--------------|-------------|-------------|
| 80% or above         | A+           | (A Plus)    | 4.00        |
| 75% to less than 80% | A            | (A Regular) | 3.75        |
| 70% to less than 75% | A-           | (A Minus)   | 3.50        |
| 65% to less than 70% | B+           | (B Plus)    | 3.25        |
| 60% to less than 65% | B            | (B Regular) | 3.00        |
| 55% to less than 60% | B-           | (B Minus)   | 2.75        |
| 50% to less than 55% | C+           | (C Plus)    | 2.50        |
| 45% to less than 50% | C            | (C Regular) | 2.25        |
| 40% to less than 45% | C-           | (C Minus)   | 2.00        |
| Less than 40%        | F            | Fail        | 0.00        |

**Examination System**

Students will be evaluated continually throughout the semester. For theoretical classes, they will be assessed by class participation, assignments, quizzes, presentations, mid-semester examinations, and final examination. For laboratory work students will be assessed by observing them at work, presentations, viva-voce during laboratory works, from their written reports and grades of examinations designed by the respective teachers.

## Theory Course Assessment Methods

### Class Attendance

Class attendance carries 10% of total marks.

### Midterm Examination

There will be two mid semester examinations within the total lecture period. Each midterm examination will be of 20% marks. First midterm examination will be held after completion of one-third of the course content and second midterm will be held after the completion of the next one-third of the course. The average marks obtained from these two midterm examinations will be added to the total marks.

### Assessment

There will be quiz/MCQ/short/fill/assignment within the total lecture period. The assessment will be of 10% marks.

### Final Examination

For a 3 or 4 credit course, the question paper will contain eight questions in two equal groups from which the students will be asked to attempt any five taking at least two from each group. In a 1 or 2 credit course, the question paper will contain six questions in two equal groups from which the students will be asked to attempt any four taking two from each group. The final examination bears 60% weight of total marks. The questions will be designed to test specific knowledge of the courses. Each question may contain two/three parts, the first part will be concept and theory based and the other part(s) will be problem solving or analytical. For 1 or 2 credit courses the duration of final examination will be two hours and that for 3 or 4 credit courses the duration will be three hours.

*The semester system will be followed as per university semester ordinance, examination ordinance and subsequent amendments made by the academic council.*

The B.Sc. (Honours) program in Statistics is spread over four academic years carrying 143 credits in total as per semester ordinance of the university. A pre-requisite course must be completed before taking higher level course where such requirement is mentioned in course outline.

## Course Outline

### First Year First Semester

| Course No.     | Course Title                                       | Hours/Week (Theory + Lab) | Credits |
|----------------|----------------------------------------------------|---------------------------|---------|
| <u>STA151</u>  | Principles of Statistics                           | 3 + 0                     | 3.0     |
| <u>STA151L</u> | Principles of Statistics Lab                       | 0 + 4                     | 2.0     |
| <u>MAT101O</u> | Basic Algebra                                      | 2 + 0                     | 2.0     |
| <u>ENG101O</u> | Effective Communication in English                 | 2 + 0                     | 2.0     |
| <u>SSS100</u>  | History of the Emergence of Independent Bangladesh | 3 + 0                     | 3.0     |
| <u>STA100A</u> | Presentation & Viva-voce                           | 0 + 0                     | 1.0     |
|                | Total                                              | 10 + 4                    | 13.0    |

### First Year Second Semester

| Course No.     | Course Title                | Hours/Week (Theory + Lab) | Credits |
|----------------|-----------------------------|---------------------------|---------|
| <u>STA152</u>  | Introduction to Probability | 3 + 0                     | 3.0     |
| <u>STA154</u>  | Sampling Techniques – I     | 3 + 0                     | 3.0     |
| <u>STA154L</u> | Sampling Techniques – I Lab | 0 + 4                     | 2.0     |
| <u>MAT103O</u> | Calculus                    | 3 + 0                     | 3.0     |
| <u>MAT109O</u> | Linear Algebra              | 3 + 0                     | 3.0     |
| <u>ENG103O</u> | Academic Writing            | 2 + 0                     | 2.0     |
| <u>STA100B</u> | Presentation & Viva-voce    | 0 + 0                     | 1.0     |
|                | Total                       | 14 + 4                    | 17.0    |

### Second Year First Semester

| Course No.     | Course Title                               | Hours/Week (Theory + Lab) | Credits |
|----------------|--------------------------------------------|---------------------------|---------|
| <u>STA251</u>  | Probability Distributions                  | 3 + 0                     | 3.0     |
| <u>STA253</u>  | Theory of Statistics                       | 3 + 0                     | 3.0     |
| <u>STA253L</u> | Theory of Statistics Lab                   | 0 + 4                     | 2.0     |
| <u>MAT207O</u> | Advanced Calculus & Differential Equations | 3 + 0                     | 3.0     |
| <u>ECO201O</u> | Principles of Microeconomics               | 3 + 0                     | 3.0     |
| <u>STA200A</u> | Presentation & Viva-voce                   | 0 + 0                     | 1.0     |
|                | Total                                      | 12 + 4                    | 15.0    |

**Second Year Second Semester**

| Course No.     | Course Title                          | Hours/Week (Theory + Lab) | Credits |
|----------------|---------------------------------------|---------------------------|---------|
| <u>STA252</u>  | Regression Analysis – I               | 3 + 0                     | 3.0     |
| <u>STA252L</u> | Regression Analysis – I Lab           | 0 + 4                     | 2.0     |
| <u>MAT208O</u> | Numerical Methods                     | 2 + 0                     | 2.0     |
| <u>MAT209O</u> | Real Analysis                         | 2 + 0                     | 2.0     |
| <u>ECO202O</u> | Principles of Macroeconomics          | 3 + 0                     | 3.0     |
| <u>CSE205O</u> | Database Management & Programming     | 2 + 0                     | 2.0     |
| <u>CSE206O</u> | Database Management & Programming Lab | 0 + 6                     | 3.0     |
| <u>STA200B</u> | Presentation & Viva-voce              | 0 + 0                     | 1.0     |
|                | Total                                 | 12 + 10                   | 18.0    |

**Third Year First Semester**

| Course No.     | Course Title                             | Hours/Week (Theory + Lab) | Credits |
|----------------|------------------------------------------|---------------------------|---------|
| <u>STA351</u>  | Design & Analysis of Experiments – I     | 3 + 0                     | 3.0     |
| <u>STA351L</u> | Design & Analysis of Experiments – I Lab | 0 + 4                     | 2.0     |
| <u>STA353</u>  | Statistical Inference                    | 3 + 0                     | 3.0     |
| <u>STA353L</u> | Statistical Inference Lab                | 0 + 4                     | 2.0     |
| <u>STA355</u>  | Statistical Computing – I                | 2 + 0                     | 2.0     |
| <u>STA355L</u> | Statistical Computing – I Lab            | 0 + 4                     | 2.0     |
| <u>STA357</u>  | Linear Programming                       | 3 + 0                     | 3.0     |
| <u>STA357L</u> | Linear Programming Lab                   | 0 + 4                     | 2.0     |
| <u>STA300A</u> | Presentation & Viva-voce                 | 0 + 0                     | 1.0     |
|                | Total                                    | 11 + 16                   | 20.0    |

**Third Year Second Semester**

| Course No.     | Course Title                                                 | Hours/Week (Theory + Lab) | Credits |
|----------------|--------------------------------------------------------------|---------------------------|---------|
| <u>STA352</u>  | Stochastic Processes (Pre-requisites STA152, STA251)         | 3 + 0                     | 3.0     |
| <u>STA352L</u> | Stochastic Processes Lab (Pre-requisites STA152, STA251)     | 0 + 2                     | 1.0     |
| <u>STA354</u>  | Demography                                                   | 3 + 0                     | 3.0     |
| <u>STA354L</u> | Demography Lab                                               | 0 + 4                     | 2.0     |
| <u>STA356</u>  | Statistical Computing – II                                   | 2 + 0                     | 2.0     |
| <u>STA356L</u> | Statistical Computing – II Lab                               | 0 + 4                     | 2.0     |
| <u>STA358</u>  | Regression Analysis – II (Pre-requisite STA252, STA252L)     | 3 + 0                     | 3.0     |
| <u>STA358L</u> | Regression Analysis – II Lab (Pre-requisite STA252, STA252L) | 0 + 4                     | 2.0     |
| <u>STA360</u>  | Field Work                                                   | 7 Days                    | 1.0     |
| <u>STA300B</u> | Presentation & Viva-voce                                     | 0 + 0                     | 1.0     |
|                | Total                                                        | 11 + 14                   | 20.0    |

**Fourth Year First Semester**

| Course No.     | Course Title                                                              | Hours/Week (Theory + Lab) | Credits |
|----------------|---------------------------------------------------------------------------|---------------------------|---------|
| <u>STA451</u>  | Economic Statistics                                                       | 3 + 0                     | 3.0     |
| <u>STA451L</u> | Economic Statistics Lab                                                   | 0 + 4                     | 2.0     |
| <u>STA453</u>  | Applied Statistics                                                        | 3 + 0                     | 3.0     |
| <u>STA453L</u> | Applied Statistics Lab                                                    | 0 + 4                     | 2.0     |
| <u>STA455</u>  | Design & Analysis of Experiments – II (Pre-requisite STA351, STA351L)     | 3 + 0                     | 3.0     |
| <u>STA455L</u> | Design & Analysis of Experiments – II Lab (Pre-requisite STA351, STA351L) | 0 + 4                     | 2.0     |
| <u>STA457</u>  | Sampling Techniques – II (Pre-requisite STA154, STA154L)                  | 3 + 0                     | 3.0     |
| <u>STA457L</u> | Sampling Techniques – II Lab (Pre-requisite STA154, STA154L)              | 0 + 2                     | 1.0     |
| <u>STA400A</u> | Presentation & Viva-voce                                                  | 0 + 0                     | 1.0     |
|                | Total                                                                     | 12 + 14                   | 20.0    |

**Fourth Year Second Semester**

| Course No.     | Course Title                                                  | Hours/Week (Theory + Lab) | Credits |
|----------------|---------------------------------------------------------------|---------------------------|---------|
| <u>STA452</u>  | Multivariate Analysis                                         | 3 + 0                     | 3.0     |
| <u>STA452L</u> | Multivariate Analysis Lab                                     | 0 + 4                     | 2.0     |
| <u>STA454</u>  | Biostatistics and Epidemiology                                | 3 + 0                     | 3.0     |
| <u>STA454L</u> | Biostatistics and Epidemiology Lab                            | 0 + 4                     | 2.0     |
| <u>STA456</u>  | Generalized Linear Models (Pre-requisite STA358, STA358L)     | 3 + 0                     | 3.0     |
| <u>STA456L</u> | Generalized Linear Models Lab (Pre-requisite STA358, STA358L) | 0 + 4                     | 2.0     |
| <u>STA458</u>  | Research Methodology                                          | 2 + 0                     | 2.0     |
| <u>STA460</u>  | Project (Mandatory course STA458)                             | 30 Days                   | 2.0     |
| <u>STA400B</u> | Presentation & Viva-voce                                      | 0 + 0                     | 1.0     |
|                | Total                                                         | 11 + 12                   | 20.0    |

**Optional Courses**

| Course No.    | Course Title       | Hours/Week (Theory + Lab) | Credits |
|---------------|--------------------|---------------------------|---------|
| <u>STA491</u> | Comprehensive – I  | 3 + 0                     | 3.0     |
| <u>STA492</u> | Comprehensive – II | 3 + 0                     | 3.0     |

## Detailed Course Curriculum

### First Year First Semester Course Details

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 1 <sup>st</sup> Semester | STA151     | Principles of Statistics | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on introductory statistical concepts.

#### Objectives

- Provide a good intuitive understanding of statistical principles and descriptive methods,
- Make students understand the basic concepts of probability,
- Help students conceptualize introductory concepts of bivariate data analysis.
- Acquaint students with various ways of measuring statistical data.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Explain various types of data, scale of measurement, construction of frequency distribution, and graphical presentation of data;
- CLO2 Derive and calculate different measures of central tendency, location, dispersion, shape characteristics;
- CLO3 Solve basic problems on probability;
- CLO4 Define and distinguish correlation and regression analysis;
- CLO5 Explain and evaluate the association of attributes.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       | √     |       |       |       |       |        |
| CLO2        | √     |       | √     |       | √     |       |       |       |       |        |
| CLO3        | √     |       | √     | √     |       |       |       |       |       |        |
| CLO4        | √     | √     | √     |       | √     |       |       |       |       |        |
| CLO5        | √     |       | √     |       | √     |       |       |       |       |        |

#### Contents of the Course

Basic statistics: meaning and scope of Statistics, variables and attributes, scales of measurement, frequency distribution, stem and leaf analysis and graphical representation. Summarization of data: central tendency, dispersion and their measures, moments, skewness, kurtosis and their measures, five number summary, box and whisker plots.

Association of attributes: basic ideas, independence, association and disassociation, measures of association, partial association, contingency table, association in  $r \times c$  contingency table, Pearson's correlation, Spearman's rank correlation, Kendall tau correlation and coefficient of concordance. Concept of simple linear regression.

#### Main Texts

1. Mostafa, M. G., (1989), Methods of Statistics, Karim Press and Publication, Dhaka, Bangladesh
2. Ross S. M., (2010), Introductory Statistics, 3<sup>rd</sup> Edition, Academic Press, USA

3. Weiss N. A., (2016), Introductory Statistics, 10<sup>th</sup> Edition, Pearson
4. Rahman M. S., (2020), Statistics and Probability: An Introductory Analysis, Kazi Prokashoni, Dhaka

#### Reference Books

1. Gupta S. C. & Kapoor V. K., (2000), Fundamentals of Mathematical Statistics, 10<sup>th</sup> Revised Edition, Sultan Chand and Sons, New Delhi, India
2. Islam M N, (2006), Introduction to Statistics and Probability, 3<sup>rd</sup> Edition, Book World, Dhaka
3. Ross S. M., (2018), A First Course in Probability, 9<sup>th</sup> Edition, Academic Press, NY
4. Roy M. K., (2011), Fundamentals of Probability and Probability Distributions, 8<sup>th</sup> Edition, ROMAX Publications, Chittagong

| Year                 | Semester                 | Course No. | Course Title                 | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|------------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 1 <sup>st</sup> Semester | STA151L    | Principles of Statistics Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge to explore data.

#### Objectives

- Provide knowledge on exploratory data analysis,
- Make students understand bivariate data analysis.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Construct frequency distribution and present data graphically;
- CLO2 Compute and interpret measures of central tendency, location, dispersion, and shape characteristics;
- CLO3 - Quantify association of attributes;
- CLO4 Perform correlation and regression analysis;

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       | √     |       |       | √     | √     |        |
| CLO2        | √     |       | √     |       | √     |       |       | √     | √     |        |
| CLO3        | √     |       | √     | √     |       |       |       | √     | √     |        |
| CLO4        | √     | √     | √     |       | √     |       |       | √     | √     |        |

#### Contents of the Course

Condensation and tabulation of data, frequency distribution, graphical representation of data, measures of central tendency, dispersion, skewness and kurtosis, measures of association, correlation and regression.

#### Main Texts

1. Ross S. M., (2010), Introductory Statistics, 3<sup>rd</sup> Edition, Academic Press, USA
2. Mostafa, M. G., (1989), Methods of Statistics, Karim Press and Publication, Dhaka, Bangladesh

- Rahman M. S., (2020), Statistics and Probability: An Introductory Analysis, Kazi Prokashoni, Dhaka

#### Reference Books

- Weiss N. A., (2016), Introductory Statistics, 10<sup>th</sup> Edition, Pearson
- Gupta S. C. & Kapoor V. K., (2000), Fundamentals of Mathematical Statistics, 10<sup>th</sup> Revised Edition, Sultan Chand and Sons, New Delhi, India
- Islam M N, (2006), Introduction to Statistics and Probability, 3<sup>rd</sup> Edition, Book World, Dhaka
- Ross S. M., (2018), A First Course in Probability, 9<sup>th</sup> Edition, Academic Press, NY
- Gupta S. P., (2000), Practical Statistics, S. Chand & Company Ltd., New Delhi
- Roy M. K., (2011), Fundamentals of Probability and Probability Distributions, 8<sup>th</sup> Edition, ROMAX Publications, Chittagong

| Year                 | Semester                 | Course No. | Course Title  | Hours/Week<br>(Theory + Lab) | Credits |
|----------------------|--------------------------|------------|---------------|------------------------------|---------|
| 1 <sup>st</sup> Year | 1 <sup>st</sup> Semester | MAT101O    | Basic Algebra | 2 + 0                        | 2.0     |

**Rationale of the Course:** Acquiring knowledge regarding higher Algebra, that are frequently used in higher level of statistics education.

#### Objectives

- Make students understand the set theory,
- Provide knowledge of complex numbers,
- Acquaint students with basic tools of different trigonometric series,
- Helping students conceptualize the basic theories of inequalities,
- Facilitate necessary knowledge on linear equations of different orders.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Apply set theory in solving probability problems;  
 CLO2 Employ complex numbers in solving statistical problems;  
 CLO3 Outline the necessity and usefulness of different algebraic expressions, equations and models;  
 CLO4 Employ inequalities in developing statistical theories;  
 CLO5 Demonstrate how trigonometric series can be useful in statistics.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          |          |          | √        |          |          |          |          |           |
| CLO2        | √        |          |          |          |          |          |          |          |          |           |
| CLO3        | √        |          | √        |          | √        | √        |          |          |          |           |
| CLO4        | √        |          | √        |          | √        |          |          |          |          |           |
| CLO5        |          |          |          |          | √        |          |          |          |          |           |

#### Contents of the Course

**Sets:** Ideas of set, subset, superset, power set and product set; basic set operations, real number system. **Complex numbers:** Complex numbers and their properties, De Moivre's theorem and its application, nth roots. **Summation of trigonometric series:** Method of difference, C+iS method. **Inequalities:** Properties and solutions of inequalities with their geometrical representations; Inequalities involving mean; Inequalities of Weierstrass, Cauchy, Tchebyshev and Jensen. **Theory of equations:** Polynomial and division algorithm; Fundamental theorem of algebra; Relations between roots and coefficients; Multiple roots; Transformations of equations; Increasing or decreasing of all roots; Removal of any term of an equation; Synthetic division; Nature of the roots; Descartes's rule of signs.

#### Main Text

- Hall & Knight, (2019), Higher Algebra, Arihant Publications India Limited

#### Reference Books

- Abramson, J. P., et al, (2015), Algebra and Trigonometry, OpenStax College, Rice University, ISBN 1938168372, 9781938168376
- Bernard & Child, (2019), Higher Algebra, Arihant Publications India Limited
- Rahman M. A., (1994), College Higher Algebra with Trigonometry and Set Theory, Nahar Book Depot & Publications
- Shahidullah A. N. M. & Bhattacharjee P. K., (1992), A Textbook on Higher Algebra and Trigonometry, 9<sup>th</sup> Edition, Chattogram
- Lipschutz S., (1998), Set Theory and Related Topics, 2<sup>nd</sup> Edition, Schaums Outline Series, McGraw-Hill Education
- Spiegel M. R., (2009), Vector Analysis, 2<sup>nd</sup> Edition, Schaums Outline Series, McGraw-Hill Education

| Year                 | Semester                 | Course No. | Course Title                       | Hours/Week<br>(Theory + Lab) | Credits |
|----------------------|--------------------------|------------|------------------------------------|------------------------------|---------|
| 1 <sup>st</sup> Year | 1 <sup>st</sup> Semester | ENG101O    | Effective Communication in English | 2 + 0                        | 2.0     |

**Rationale of the Course:** Acquiring ability to effectively communicate in English for academic and professional purposes.

#### Objectives

- Developing oral and written communication with grammatical accuracy,
- Facilitate communication through reading-practice.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Apply grammar rules;  
 CLO2 Produce grammatically correct meaningful sentences;  
 CLO3 Express correctly by using appropriate words, phrases, sentences or ideas;  
 CLO4 Reflect texts critically;  
 CLO5 Extract information from passages accurately.

### Mapping CLOs to PLOs

| CLO/PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1    |       |       |       | √     | √     |       | √     | √     | √     |        |
| CLO2    |       |       |       | √     | √     |       | √     | √     | √     |        |
| CLO3    |       |       |       | √     | √     |       | √     | √     | √     |        |
| CLO4    |       |       |       | √     | √     |       | √     | √     |       |        |
| CLO5    |       |       |       | √     | √     |       | √     | √     |       |        |

### Contents of the Course

Reading a selection of texts (story, essay, newspaper article, *etc.*). Forms and functions of different word categories (*e.g.* noun, verb, adjective, adverb, *etc.*). Aspects and use of tense. Subject-verb agreement. Use of infinitive, gerund, present participle, past participle, modals, causatives, conditionals, subjunctives. Use of sentence connectors/cohesion markers (*e.g.* moreover, in addition, in contrast, similarly, as a result, though, although, *etc.*). Effective combination of sentences (*e.g.* simple, complex, compound, *etc.*). Writing composition (to demonstrate grammatical competence).

### Reference Books

- Books and resources recommended by course instructors/teachers
- Liz and Soars J, Headway – Upper Intermediate (Work book and student's book)
- Cliff's TOEFL

| Year                 | Semester                 | Course No. | Course Title                                       | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|----------------------------------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 1 <sup>st</sup> Semester | SSS100     | History of the Emergence of Independent Bangladesh | 3 + 0                     | 3.0     |

### Course Objective and Learning Outcome:

The course aims to offer insight into the historical changes, the long struggle for freedom and above all the War of Independence led by the Father of the Nation Bangabandhu Sheikh Mujibur Rahman that have shaped today's Bangladesh. It is hoped that at the end of the course students will have a broader understanding and further curiosity of the rich history, culture and heritage of the country. They should also be able to appreciate the importance and relevance of history as a bridge between the past, present and the future.

### Mapping CLOs to PLOs

| CLO/ PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO      | √     |       |       |       |       |       |       |       | √     | √      |

### Contents of the Course

This course deals with the following interrelated themes and topics that are essential to understand the emergence of Bangladesh. These themes include land and people, politics, economy, governance, society, religion and culture, global connections as well as the basic topics on the freedom struggle and War of Liberation. Issues under

each of the broad themes will be discussed from the perspective of historical evolution and contemporary significance (3 credits).

#### 1. Description of the country and its people

- Impact of Geographical features in Bengal
- Ethnic composition of Bangladesh
- Development of Bengali Language and its impact
- Cultural syncretism and religious tolerance
- Distinctive identity of Bangladesh in the context of undivided Bengal

#### 2. Proposal for undivided sovereign Bengal, the partition of the Subcontinent, 1947 and Foreshadowing Bangladesh

- Rise of communalism under the colonial rule, Lahore Resolution 1940
- The proposal of Suhrawardi and Sarat Bose for undivided Bengal: consequences
- The creation of Pakistan 1947
- Foundation of Awami Muslim League and Foreshadowing Bangladesh

#### 3. Pakistan: Structure of the state and disparity

- Central and provincial structure
- Influence of Military and Civil bureaucracy
- Economic, social and cultural disparity

#### 4. Language Movement and quest for Bengali identity

- Misrule by Muslim League and Struggle for democratic politics
- The Language Movement: context, phases and International Recognition of Bengali Language
- United front of Haque – Vasani – Suhrawardi: election of 1954, consequences

#### 5. Military rule: the regimes of Ayub Khan and Yahia Khan (1958-1971)

- Definition of military rules and its characteristics
- Ayub Khan's rise to power and characteristics of his rule (Political repression, Basic democracy, Islamisation)
- Fall of Ayub Khan and Yahia Khan's rule

#### 6. Rise of nationalism and the Movement for self-determination

- Resistance against cultural aggression and resurgence of Bengali culture
- Sheikh Mujibur Rahman and the 6 points movement
- Reactions: Importance and significance
- The Agortola Case 1968

#### 7. The mass-upsurge of 1969 and 11-point movement

- Background
- Programme
- Significance

#### 8. Election of 1970 and its Impact

- Legal Framework Order (LFO)
- Programme of different political parties
- Election result and centres refusal to comply

#### 9. Non-Cooperation Movement and 7th March Speech, 1971

- The non-cooperation movement

- b. Speech of 7th March: Background of the speech, major characteristics of the speech, impact of this speech
- c. International recognition of 7<sup>th</sup> March Speech as part of world heritage

#### 10. Declaration of Independence of Bangladesh

- a. Operation Searchlight
- b. Declaration of Independence of Bangladesh by Bangabandhu
- c. Beginning of the Liberation War of Bangladesh

#### 11. The war of Liberation 1971

- a. Genocide, repression of women, refugees
- b. Formation of Bangladesh government and proclamation of Independence
- c. The spontaneous early resistance and subsequent organized resistance (Mukti Fouz, Mukti Bahini, guerillas and the frontal warfare)
- d. Publicity Campaign in the war of Liberation (Shadhin Bangla Betar Kendra, the Campaigns abroad and formation of public opinion)
- e. Contribution of students, women and the masses (Peoples war) and different political parties
- f. The role of Great powers and the United Nations in the Liberation war
- g. The contribution of India in the Liberation War
- h. The Anti-liberation activities of the occupation army, the Peace Committee, Al-Badar, Al-Shams, Rajakars, pro Pakistan political parties and Pakistani Collaborators, killing of the intellectuals
- i. Trial of Bangabandhu and reaction of the World Community
- j. Formation of joint command and the Victory
- k. The overall contribution of Bangabandhu in the Independence struggle

#### 12. The Bangabandhu Regime 1972-1975

- a. Homecoming
- b. Making of the constitution
- c. Reconstruction of the war-ravaged country
- d. Foreign Policy of Bangabandhu
- e. The murder of Bangabandhu and his family and the ideological turn-around

#### Recommended Texts

1. Ahmed Salahuddin and Bazlul Mobin Chowdhury (eds.): Bangladesh: National Culture and Heritage: An Introductory Reader (Dhaka: Independent University Bangladesh, 2004)
2. Harun-or-Roshid: The Foreshadowing of Bangladesh: Bengal Muslim League and Muslim Politics, 1906-1947 (Dhaka: The University Press Limited 2012)
3. Jahan Rounaq: Pakistan: Failure in National Integration, (Dhaka: The University Press Limited 1977)
4. Maniruzzaman Talukder: Radical Politics and the Emergence of Bangladesh, (Dhaka: Mowla Brothers, 2003)
5. Muhith, A M A: History of Bangladesh: A Subcontinental Civilization, (Dhaka: UPL, 2016)
6. Samad Abdus: History of Liberation War of Bangladesh, (Dhaka: Aparajeyo Bangla Prakashani, 2019)
7. Milton Kumar Dev, Md. Abdus Samad, History of Bangladesh, (Dhaka: Biswabidyalaya Prokasoni, 2014)

8. Schendel, Willem van: A History of Bangladesh (Cambridge: Cambridge University Press, 2009)
৯. নীহার রঞ্জন রায় : বাঙালীর ইতিহাস, (কলকাতা : দে' জ পাবলিশিং, ১৪০২ বঙ্গাব্দ)
১০. সালাহুদ্দিন আহমেদ ও অন্যান্য (সম্পাদিত) : বাংলাদেশের মুক্তি সংগ্রামের ইতিহাস ১৯৪৭-১৯৭১ (ঢাকা: আগামী প্রকাশনী, ২০০২)
১১. আবুল মাল আবদুল মুহিত : বাংলাদেশ : জাতিরাষ্ট্রের উদ্ভব (ঢাকা : সাহিত্য প্রকাশ, ২০০০)
১২. সিরাজুল ইসলাম (সম্পাদিত): বাংলাদেশের ইতিহাস ১৭০৪-১৯৭১, ৩ খন্ড (ঢাকা : এশিয়াটিক সোসাইটি অব বাংলাদেশ, ১৯৯২)
১৩. মুনতাসীর মামুন ও অন্যান্য : স্বাধীন বাংলাদেশের অভ্যুদয়ের ইতিহাস (ঢাকা : সুবর্ণ, ২০১৭)
১৪. ড. আবু মো. দেলোয়ার হোসেন : স্বাধীন বাংলাদেশের অভ্যুদয়ের ইতিহাস (ঢাকা : বিশ্ববিদ্যালয় প্রকাশনী, ২০১৪)
১৫. ড. আবু মো. দেলোয়ার হোসেন, ড. মোহাম্মদ সেলিম (সম্পাদনা) : বাংলাদেশ ও বহির্বিশ্বে (ঢাকা : বাংলাদেশ ইতিহাস সমিতি, ২০১৫)
১৬. ড. আবু মো. দেলোয়ার হোসেন : বাংলাদেশের ইতিহাস, ১৯০৫-১৯৭১ (ঢাকা : বিশ্ববিদ্যালয় প্রকাশনী, ২০১৬)
১৭. আশফাক হোসেন : স্বাধীন বাংলাদেশের অভ্যুদয়ের ইতিহাস (ঢাকা : প্রতিশ্রুতি প্রকাশন, ২০১৯)
১৮. আশফাক হোসেন : বাংলাদেশের মুক্তিযুদ্ধ ইন্দিরা গান্ধী (ঢাকা : সুবর্ণ প্রকাশনী, ২০১৭)
১৯. শেখ মুজিবুর রহমান : অসমাপ্ত আত্মজীবনী (ঢাকা : দি ইউনিভার্সিটি প্রেস লিমিটেড, ২০১২)
২০. হারুন-অর-রশিদ : বঙ্গীয় মুসলিম লীগ পাকিস্তান আন্দোলন বাঙালির রাষ্ট্র ভাবনা ও বঙ্গবন্ধু (ঢাকা : অন্যপ্রকাশ, ২০১৮)
২১. হাসান হাফিজুর রহমান: বাংলাদেশের স্বাধীনতা যুদ্ধদলিল পত্র, (সম্পাদিত) (ঢাকা : গণপ্রজাতন্ত্রী বাংলাদেশ সরকার, ১৯৮৫)
২২. সৈয়দ আনোয়ার হোসেন : বাংলাদেশের স্বাধীনতা যুদ্ধে পরাজিতের ভূমিকা (ঢাকা : ডানা প্রকাশনী, ১৯৮২)
২৩. আশফাক হোসেন : বাংলাদেশের মুক্তিযুদ্ধ ও জাতিসংঘ (ঢাকা : বাংলা একাডেমি, ২০০৩)

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 1 <sup>st</sup> Semester | STA100A    | Presentation & Viva-voce | 0 + 0                     | 1.0     |

**Rationale of the course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

#### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Develop verbal communication and presentation skills;
- CLO2 Communicate their learning effectively and appropriately to formal audiences;
- CLO3 Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;
- CLO4 Prepare for professional oral examinations which is useful to enhance employment interview skills;
- CLO5 Demonstrate their ability to participate in academic discussion.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO2        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO3        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO4        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO5        | √        | √        |          |          | √        |          |          | √        | √        | √         |

**Contents of the Course:** Comprehensive contents of all the underlying courses of the semester.

### Main Text

- Textbooks referred for all the underlying courses of the semester.

### Reference Books

- Reference books referred for all the underlying courses of the semester.

### First Year Second Semester Course Details

| Year                 | Semester                 | Course No. | Course Title                | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 2 <sup>nd</sup> Semester | STA152     | Introduction to Probability | 3 + 0                     | 3.0     |

**Rational of the Course:** Acquiring knowledge on basic probability.

### Objectives

- Make students understand the fundamental concepts of probability,
- To enhance skills of elementary mathematics,
- Facilitate necessary knowledge on theorems of basic probability,
- Helping students to develop ability in applications and methods of basic probability,
- To provide the knowledge on theoretical problem-solving skills.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Demonstrate basic probability axioms and rules and the moments of discrete and continuous random variables as well as be familiar with common named discrete and continuous random variables;
- CLO2 Derive the probability density function of transformations of random variables and use these techniques to generate data from various distributions;
- CLO3 Calculate probabilities, and derive the marginal and conditional distributions of bivariate random variables;
- CLO4 Solve real-world problems with probability models;
- CLO5 Apply appropriate inequality for solving problems related to probability;
- CLO6 Calculate conditional expectation and conditional variance;
- CLO7 Differentiate between prior and posterior probabilities.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          |          | √        |          |          | √        |          |          |           |
| CLO2        | √        |          |          | √        |          |          | √        |          |          |           |
| CLO3        | √        | √        |          | √        | √        | √        | √        |          |          |           |
| CLO4        | √        | √        |          | √        | √        | √        | √        |          |          | √         |
| CLO5        | √        |          |          |          |          |          |          |          |          | √         |
| CLO6        | √        |          |          |          |          |          |          |          |          |           |
| CLO7        | √        |          |          |          |          |          |          |          |          |           |

### Contents of the Course

Sets and their properties, experiment, random experiment, sample space, events, union and intersection of events, different types of events, probability of events, classical approach of probability, empirical approach of probability, axiomatic development of probability, conditional probability, independence of events, additive and multiplicative laws of probability. Theorem of total probability and compound probability, Bayes' theorem, realization of  $m$  among  $n$  events. Solving probability problems. Random variables: definition, probability function, distribution function, joint, marginal and conditional probability functions. Mathematical expectation: expectation and variance of a random variable, properties of mathematical expectation and variance, conditional expectation and conditional variance, covariance and correlation, Chebyshev's and Markov inequalities. Moments, moment generating function, and characteristic function. Introduction to probability distributions.

### Main Texts

- Islam M N, (2006), Introduction to Statistics and Probability, 3rd Edition, Book World, Dhaka
- Roy M. K., (2011), Fundamentals of Probability and Probability Distributions, 8<sup>th</sup> Edition, ROMAX Publications, Chittagong
- Ross S. M., (2018), A First Course in Probability, 9<sup>th</sup> Edition, Academic Press, NY
- Rahman M. S., (2020), Statistics and Probability: An Introductory Analysis, Kazi Prokashoni, Dhaka

### Reference Books

- Gupta S. C. & Kapoor V. K., (2000), Fundamentals of Mathematical Statistics, 10<sup>th</sup> Edition, Sultan Chand and Sons, New Delhi, India
- Hoq A. K. M. S., (1996), Probability: An Introduction, 1<sup>st</sup> Edition, Dhaka
- Meyer A., Probability and Statistics, Addison-Wesley, USA
- Mostafa M. G., (1989), Methods of Statistics, Karim press and publication, Dhaka Bangladesh
- Mosteller et al, Probability with Statistical Applications, 2<sup>nd</sup> Edition, Addison-Wesley, USA
- Parzen E, Modern Probability Theory and Its Applications, John Wiley, NY

| Year                 | Semester                 | Course No. | Course Title            | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 2 <sup>nd</sup> Semester | STA154     | Sampling Techniques – I | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge of sampling, sampling techniques, census, survey design and method of data collection.

### Objectives

- To familiarize students with the concepts of sampling, sampling techniques, census, survey design and methods of data collection,
- Help students conceptualize different sampling techniques such as simple random sampling, stratified random sampling, systematic sampling, cluster sampling,
- To facilitate necessary knowledge to compare the efficiency among different sampling techniques,
- Help students properly apply knowledge to select appropriate sampling technique for collecting data according to the requirement of problems to be analyzed.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Prepare layouts of different sampling techniques;  
 CLO2 - Apply methods and analytical tools for collecting data;  
 CLO3 - Collaborate in a project for collecting primary data;  
 CLO4 -Assess the quality of collected data;  
 CLO5 - Produce necessary estimates of parameters;  
 CLO6 - Calculate efficiency of the estimates;  
 CLO7 - Construct confidence intervals of the estimates;  
 CLO8 - Compare efficiency of alternative sampling designs.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     | √     | √     |       |       |       | √     | √     |       | √      |
| CLO2        | √     | √     | √     |       |       |       | √     | √     |       | √      |
| CLO3        | √     | √     | √     |       |       |       | √     | √     |       | √      |
| CLO4        | √     | √     | √     |       |       |       | √     | √     |       | √      |
| CLO5        | √     | √     | √     |       |       |       | √     | √     |       | √      |
| CLO6        | √     | √     | √     |       |       |       | √     | √     |       | √      |
| CLO7        | √     | √     | √     |       |       |       | √     | √     |       | √      |
| CLO8        | √     | √     | √     |       |       |       | √     | √     |       | √      |

### Contents of the Course

Concept and scope of sampling, sampling versus census, steps of survey, questionnaire, pilot survey, probability and non-probability sampling, sampling and non-sampling errors, bias and precision, determination of sample size.

Random sampling design: simple random sampling, stratified random sampling, post stratification, systematic sampling, cluster sampling. Estimation of population total, mean, proportion and their standard errors. Ratio and regression methods of estimation. PPS sampling: comparison with sampling with equal probabilities. Selection of clusters with equal probability and unequal probability with and without replacement.

Non-probability sampling: purposive sampling, judgement sampling, quota sampling, snowball sampling: merits, demerits and applications.

### Main Texts

1. Cochran W. G., (1977), Sampling Techniques, 3<sup>rd</sup> Edition, John Wiley, NY
2. Lohr S. L., (2010), Sampling: Design and Analysis, 2<sup>nd</sup> Edition, MPS Limited, Macmillan, USA

### Reference Books

1. Des Raj, (1968), Sampling Theory, Tata McGraw-Hill, Delhi
2. Islam M. N., (2005), An Introduction to Sampling Methods, 1<sup>st</sup> Edition, Book World, Dhaka.
3. Kish L., (1968), Survey Sampling, Wiley, 1<sup>st</sup> Edition, NY
4. Sukhatme P. V., (1984), Sampling Theories and Surveys with Applications, 3<sup>rd</sup> Edition, Iowa State University Press, USA

| Year                 | Semester                 | Course No. | Course Title                | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 2 <sup>nd</sup> Semester | STA154L    | Sampling Techniques – I Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge to draw sample from population using different sampling techniques and collect data.

### Objectives

- Help students develop ability to draw sample using different sampling techniques such as simple random sampling, stratified random sampling, systematic sampling, cluster sampling;
- Make students capable to measure the efficiencies of different sampling techniques and compare them.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Determine appropriate methods and analytical tools for collecting data;  
 CLO2 - Draw sample from population through different sampling techniques;  
 CLO3 - Collect primary data from different sources for various purposes;  
 CLO4 -Assess quality of the collected data;  
 CLO5 - Produce necessary estimates of parameters;  
 CLO6 - Calculate efficiency of the estimates;  
 CLO7 - Construct confidence intervals of the estimates;  
 CLO8 - Compare efficiency of alternative sampling designs.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO2        | √        | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO3        | √        | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO4        | √        | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO5        | √        |          | √        |          | √        | √        | √        | √        | √        | √         |
| CLO6        | √        |          | √        |          | √        | √        | √        | √        | √        | √         |
| CLO7        | √        |          | √        |          | √        | √        | √        | √        | √        | √         |
| CLO8        | √        |          | √        |          | √        |          | √        | √        | √        | √         |

### Contents of the Course

**Random sampling design:** simple random sampling, stratified random sampling, systematic sampling, and cluster sampling.

**PPS sampling:** comparison with sampling with equal probabilities. Selection of clusters with equal probability and unequal probability with and without replacement.

### Main Texts

1. Cochran W. G., (1977), Sampling Techniques, 3<sup>rd</sup> Edition, John Wiley, NY
2. Lohr S. L., (2010), Sampling: Design and Analysis, 2<sup>nd</sup> Edition, MPS Limited, Macmillan, USA

### Reference Books

1. Des Raj, (1968), Sampling Theory, Tata McGraw-Hill, Delhi
2. Islam M. N., (2005), An Introduction to Sampling Methods, 1<sup>st</sup> Edition, Book World, Dhaka.
3. Kish L., (1968), Survey Sampling, Wiley, 1<sup>st</sup> Edition, NY
4. Sukhatme P. V., (1984), Sampling Theories and Surveys with Applications, 3<sup>rd</sup> Edition, Iowa State University Press, USA

| Year                 | Semester                 | Course No. | Course Title | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 2 <sup>nd</sup> Semester | MAT103O    | Calculus     | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring solid foundations for applications of calculus in statistical theory.

### Objectives

- To make students understand the basic concepts of differential and integral calculus,
- To help students for solving statistical problems using necessary calculus.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Define the basic concepts and principles of differential and integral calculus of real functions and sequences and series;
- CLO2 Interpret the geometric meaning of differential and integral calculus;
- CLO3 Apply the concept and principles of differential and integral calculus to solve geometric and physical problems
- CLO4 Analyze the properties of functions using graphs;
- CLO5 Organize solving of complex problems by combining the acquired mathematical concepts and principles.

### Mapping of CLOs with PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          | √        |          |          |          |          |          |           |
| CLO2        | √        | √        |          |          |          |          |          |          |          |           |
| CLO3        | √        |          | √        |          |          |          |          |          |          |           |
| CLO4        | √        | √        |          |          |          |          |          |          |          |           |
| CLO5        | √        |          |          |          |          |          |          |          |          |           |

### Contents of the Course

Differential Calculus: Functions of real variables and their graphs; limit, continuity and derivative; physical meaning of derivative of a function; higher derivatives; Leibnitz's theorem; Rolle's theorem; mean value theorem; Taylor's theorem; Taylor's and Maclaurin's series without proofs; maximum and minimum values of a function; functions of two and three variables; partial and total derivatives; concavity and convexity of a function.

Integral Calculus: Physical meaning of integration of a function; evaluation of indefinite integrals; definition of Riemann integral; fundamental theorem of integral calculus and its application to definite integrals; double and triple integration; application of integration in finding lengths, areas and volumes.

### Main Text:

Anton, H. (1995). Calculus with Analytic Geometry, 5<sup>th</sup> Edition, John Wiley and Sons, NY, USA.

### Reference Books

1. Das & Mukherjee, Differential Calculus, 52<sup>nd</sup> Edition, U. N. Dhur & Sons Limited, Kolkata
2. Das & Mukherjee, Integral Calculus, U. N. Dhur & Sons Limited, Kolkata
3. Swokowski E W, Calculus with Analytic Geometry, 2<sup>nd</sup> Edition, Wadsworth Inc, USA
4. Thomas & Finney, Calculus and Analytic Geometry, 9<sup>th</sup> Edition, Pearson Education Inc and Dorling Kinderslay Publishing Inc, New Delhi
5. Tierney, Calculus with Analytic Geometry, 3<sup>rd</sup> Edition, Allyn & Bacon Inc, USA

| Year | Semester | Course No. | Course Title | Hours/Week (Theory + Lab) | Credits |
|------|----------|------------|--------------|---------------------------|---------|
|------|----------|------------|--------------|---------------------------|---------|

|                         |                             |         |                |       |     |
|-------------------------|-----------------------------|---------|----------------|-------|-----|
| 1 <sup>st</sup><br>Year | 2 <sup>nd</sup><br>Semester | MAT1090 | Linear Algebra | 3 + 0 | 3.0 |
|-------------------------|-----------------------------|---------|----------------|-------|-----|

**Rationale of the Course:** Acquiring knowledge of linear algebra to solve problems on different statistical models.

#### Objectives

- Acquaint students with basic concepts of matrices and matrix algebra,
- Facilitate necessary knowledge on methods of solving systems of linear equations,
- Make students understand the basic concepts of vector spaces,
- Provide knowledge on concepts of linear transformations,
- Help students conceptualize operations in matrix and describe their properties,
- Facilitate understanding on methods of computing using eigenvalues and eigenvectors.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Solve systems of linear equations;

CLO2 - Calculate with matrices;

CLO3 - Describe the concept of vector spaces;

CLO4 - Calculate determinants and understand their meaning;

CLO5 - Calculate and apply eigenvalues and eigenvectors;

CLO6 - Describe linear transformations and find their matrices;

CLO7 - Apply linear algebra to discrete calculus, graphs and networks.

#### Mapping of CLOs with PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          |          |          |          |          |          |          |           |
| CLO2        | √        | √        |          |          |          |          |          |          |          |           |
| CLO3        | √        | √        |          |          |          |          |          |          |          |           |
| CLO4        | √        | √        |          |          |          |          |          |          |          |           |
| CLO5        | √        | √        |          |          |          |          |          |          |          |           |
| CLO6        | √        | √        |          |          |          |          |          |          |          |           |
| CLO7        | √        | √        |          |          |          |          |          |          |          |           |

#### Contents of the Course

Matrix: definition of a matrix, different types of matrices, addition and multiplication of matrices. Adjoint and inverse of matrix, Cramer's rule, application of inverse matrix and Cramer's rule. Elementary row operations and echelon forms of matrices, rank, row rank, column rank of a matrix and their equivalence, use of rank and echelon forms in solving system of homogeneous and nonhomogeneous equations. g-inverse. Vector space and subspace over reals and direct sum, linear combination, linear dependence and independence of vectors, basis and dimension of vector space, quotient space and isomorphism theorems, linear transformations, kernel, rank and nullity nonsingular transformations and matrix representation, changes of basis, eigenvector. Eigenvalues, characteristic equations and Cayley-Hamilton theorem. Similar matrices, canonical forms orthogonal and Hermitian matrices, inner product, orthogonal vectors and orthonormal bases, Gram-Schmidt orthogonalization process. Bilinear and quadratic forms. Kronecker sums and products of matrices.

#### Main Text:

1. Hadely G (1961), Linear Algebra, Addison-Wesley, NY
2. Searle S R, Matrix Algebra Useful for Statistics, John Wiley, NY

#### Reference Books

1. Ayres F, Theory and Problems of Matrices, Schaum's Outline Series, McGraw Hill, NY
2. Bering E D, Linear Algebra and Matrix Theory
3. Hamilton A G, Linear Algebra, 4<sup>th</sup> Edition, Cambridge University Press
4. Khanna M I & Pundir S K, Linear Algebra, 11<sup>th</sup> Edition, Jai Prakash Nath & Co, India
5. Kolman B, Elementary Linear Algebra, 9<sup>th</sup> Edition, Pearson Education Inc, New Jersey
6. Lipschutz S & Lipson M, Linear Algebra, 6<sup>th</sup> Edition, Schaum's Outline Series, McGraw Hill, NY
7. Morris A O, Linear Algebra, 2<sup>nd</sup> Edition, Chapman and Hall/CRC, USA
8. Narayan S, Mittal P K (2010), A Textbook of Matrices, Sultan Chand & Co., India.
9. Rahman M A, College Linear Algebra, 7<sup>th</sup> Edition, Nahar Book Depot & Publications

| Year                    | Semester                    | Course No. | Course Title     | Hours/Week<br>(Theory + Lab) | Credits |
|-------------------------|-----------------------------|------------|------------------|------------------------------|---------|
| 1 <sup>st</sup><br>Year | 2 <sup>nd</sup><br>Semester | ENG1030    | Academic Writing | 2 + 0                        | 2.0     |

**Rationale of Course:** Acquiring knowledge of the basics of academic writing, paragraphs, essays and letters using appropriate vocabulary and formats.

#### Objectives

- Make students understand the specifics of academic writing,
- Provide knowledge on how to write academic papers, *e.g.*, essays, assignments, reports, *etc.*,
- Facilitate proper writing of letters of complaint and job applications,
- Acquaint students with the environment to strengthen their vocabulary.

**Course Learning Outcome:** At the end of the course, students will be able to -

CLO1 - Organize ideas coherently in paragraphs and essays;

CLO2 - Create varied correspondence correctly;

CLO3 - Apply the rules of writing mechanics;

CLO4 - Employ appropriate vocabulary and phrases.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          |          |          | √        | √        |          | √        | √        |          |           |
| CLO2        |          |          |          | √        | √        |          | √        | √        |          |           |
| CLO3        |          |          |          | √        | √        |          | √        | √        |          |           |
| CLO4        |          |          |          | √        | √        |          | √        | √        |          |           |

### Contents of the Course

Features of Academic Writing style / features of academic English: Complexity, formality, precision, objectivity, explicitness, accuracy, hedging, organization, planning, impersonal, cohesive, coherent, authentic, etc.

Formal and informal English.

Features of effective paragraph: Topic sentence/introducer, developers, modulators, terminators.

Structure and types of Essays: Effective introduction. Body paragraphs. Conclusion paragraphs. Argumentative essays. Persuasive essay. Expository essays.

Formal letters on social, official and business correspondence, fax, e-mail, letters of opinion, complaint.

Report writing (academic and nonacademic): Language and format. In-text citation. Reference.

Workshop 1: Students will write a report (non-literary) either based on given data/information or conducting a survey. The report must demonstrate the specifics of academic writing.

### Books and Resources

1. Chalmers R, (2011), Academic English Course Book, Ra Chalmers Publishers
2. Hewings M., Thaine C. & McCarthy M., (2012), Cambridge Academic English C1 Advanced Student's Book: An Integrated Skills Course for Eap, Cambridge University Press
3. Imhoof M. L. & Hudson H., (1975), From Paragraph to Essay: Developing Composition Writing, Longman
4. Books and resources recommended by the course instructor(s)

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------|---------------------------|---------|
| 1 <sup>st</sup> Year | 2 <sup>nd</sup> Semester | STA100B    | Presentation & Viva-voce | 0 + 0                     | 1.0     |

**Rationale of the Course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Develop verbal communication and presentation skills;
- CLO2 Communicate their learning effectively and appropriately to formal audiences;
- CLO3 Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;
- CLO4 Prepare for professional oral examinations which is useful to enhance employment interview skills;

CLO5 Demonstrate their ability to participate in academic discussion.

### Mapping CLOs to PLOs

| CLO/ PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1     | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO2     | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO3     | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO4     | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO5     | √     | √     |       |       | √     |       |       | √     | √     | √      |

### Contents of the Course

Comprehensive contents of all the underlying courses of the semester.

### Main Text

- Textbooks referred for all the underlying courses of the semester.

### Reference Books

- Reference books referred for all the underlying courses of the semester.

### Second Year First Semester Course Details

| Year                 | Semester                 | Course No. | Course Title              | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|---------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 1 <sup>st</sup> Semester | STA251     | Probability Distributions | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge to generalize random variables with real life data.

### Objectives

- To provide knowledge on deeper concepts of the characteristics of discrete and continuous random variables and their distributions,
- Make the students understand different properties of discrete and continuous variates,
- Help the students to develop skills on applications of probability distributions to various disciplines,
- Foster the analytical and critical thinking ability to establish relationships between different probability distributions.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Differentiate the concepts of discrete and continuous random variables,
- CLO2 Formulate the functional form of both discrete and continuous random variables,
- CLO3 Calculate probabilities under different probability distributions,
- CLO4 Derive the common characteristics of various probability distributions.
- CLO5 Relate a probability distribution with some other appropriate distribution(s)
- CLO6 Translate real life problems to appropriate statistical distributions and

calculate necessary events probability

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        | √        | √        | √        | √        | √        |          |          |           |
| CLO2        | √        |          |          |          |          |          | √        |          |          |           |
| CLO3        | √        |          |          |          |          |          |          |          |          |           |
| CLO4        | √        |          |          |          |          |          |          |          |          |           |
| CLO5        | √        |          |          |          |          |          |          |          |          |           |
| CLO6        | √        |          | √        |          | √        |          |          |          |          | √         |

#### Contents of the Course

**Review of Related Concepts:** Random variable, moment generating function, characteristic function, probability generating function of a random variable; Expectation and variance of a random variable.

**Univariate Discrete Distributions:** Detail study of Bernoulli, Binomial, Poisson, Geometric, Hypergeometric, Negative Binomial, Multinomial, Rectangular distributions. Idea of Logarithmic, Beta Binomial, Generalized Negative Binomial, Negative Hypergeometric, Power Series Distributions.

**Univariate Continuous Distributions:** Detail study of, Normal, Exponential, Beta, Gamma, Uniform, Half Normal, Log Normal, Cauchy, Weibull distributions. Idea of Inverted Gamma, Inverse Gaussian, Laplace, Gumbell, Maxwell, Erlang, Pareto distributions. Pearsonian Type Curves.

**Elementary Concepts of Bivariate Distribution:** Binomial, Poisson, Geometric, Normal, Gamma and Beta.

#### Main Texts

1. Krishnamoorthy K., (2006), Handbook of Statistical Distributions with Applications, Chapman and Hall/CRC
2. Johnson, N., Kotz S. and Kemp, A., (2008), Univariate Discrete Distributions, 3rd Edition, John Wiley and Sons, New York
3. Johnson, N. and Balakrishnan N., (1995), Continuous Univariate Distribution, 2nd Edition, John Wiley and Sons, New York
4. Rahman M. S., (2020), Statistics and Probability: An Introductory Analysis, Kazi Prokashoni, Dhaka

#### Reference Books

1. Devore, J. L. (2011): Probability and Statistics for Engineering and Sciences, 8th Edition, Duxbury Press.
2. Evans, M., Hasting, N. and Peacock, B. (2000): Statistical Distributions, 3rd Edition, Wiley, New York.
3. Hogg, R. V. and Craig, A. T. (2012): Introduction of Mathematical Statistics, 7th Edition, Pearson Education, Asia
4. Islam, M. N., (2006), Introduction to Statistics and Probability, 3<sup>rd</sup> Edition, Dhaka

5. Ross, S. M. (2014): Introduction to Probability and Statistics for Engineers and Scientist, 5<sup>th</sup> Edition, Academic Press
6. Roy, M. K., (2011), Fundamentals of Probability & Probability Distributions, ROMAX Publications, Chittagong

| Year                    | Semester                    | Course No. | Course Title            | Hours/Week<br>(Theory + Lab.) | Credits |
|-------------------------|-----------------------------|------------|-------------------------|-------------------------------|---------|
| 2 <sup>nd</sup><br>Year | 1 <sup>st</sup><br>Semester | STA253     | Theory of<br>Statistics | 3 + 0                         | 3.0     |

**Rationale of the Course:** Acquiring the basic concepts of inferential statistics to analyze data.

#### Objectives

- Help students conceptualize basic theories in introductory statistical techniques and their applications in different scientific fields,
- Provide solid knowledge regarding parent and sampling distributions,
- Help students develop the capability regarding presentation, analysis and interpretation of data and results in different fields of research.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Formulate and derive various parent and sampling distributions;
- CLO2 Describe properties and interpret parameters of relevant parent and sampling distribution;
- CLO3 Produce appropriate approximation to relevant sampling distribution;
- CLO4 Formulate appropriate test statistic for testing hypotheses;
- CLO5 Analyze data and interpret results in different fields of research;
- CLO6 Relate the relevance of statistics in their different professional sectors;
- CLO7 Develop the capability regarding analysis and presentation of statistical tools.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        | √        | √        |          | √        | √        |          |           |
| CLO2        | √        |          | √        | √        |          |          |          | √        |          |           |
| CLO3        | √        |          | √        | √        |          |          |          | √        |          |           |
| CLO4        | √        |          | √        | √        |          |          |          | √        |          |           |
| CLO5        | √        |          | √        | √        |          |          |          | √        |          |           |
| CLO6        | √        |          | √        | √        |          |          |          | √        |          |           |
| CLO7        | √        |          | √        | √        |          |          |          | √        |          |           |

#### Contents of the Course

Concept of parameter and statistic, sampling distribution, transformation of variates, standard errors of statistics. Sampling from normal and non-normal populations, distribution of various statistics. Central limit theorem. Distribution of functions of random variables of continuous and discrete types, joint distribution of  $\bar{X}$  and  $s^2$ , detailed study of  $\chi^2$ , Student's t and F distributions, distribution of correlation coefficient in the null case, distribution of regression coefficient.

Order statistics, properties of order statistics, joint distribution of  $n$  order statistics, marginal distributions of order statistics, distribution of the median and range. Concept of tests of hypothesis: hypotheses, errors in testing hypotheses. Testing hypotheses for assigned mean, variance, proportion and correlation. Comparison of means, proportions, variances and correlation, Bartlett's test of homogeneity of variances. Test for correlation and regression coefficients. Exact test for  $2 \times 2$  table, test for  $r \times c$  contingency table.

#### Main Texts

1. Mood A., Graybill F., Boes D., (1974), Introduction to the Theory of Statistics, 3<sup>rd</sup> Edition, McGraw Hill, NY
2. Hogg R. V., McKean J., & Craig A. T., (2012), Introduction to Mathematical Statistics, 7<sup>th</sup> Edition, Pearson

#### Reference Books

1. Ali M. A., (1973), Theory of Statistics, Vol-II, Dhaka Book Mart
2. David H A, Nagaraja H N (2003), Order Statistics, 3<sup>rd</sup> Edition, Wiley, NY
3. Gupta S. C. & Kapoor V. K., (2000), Fundamentals of Mathematical Statistics, 10<sup>th</sup> Edition, Sultan Chand and Sons, New Delhi, India

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab.) | Credits |
|----------------------|--------------------------|------------|--------------------------|----------------------------|---------|
| 2 <sup>nd</sup> Year | 1 <sup>st</sup> Semester | STA253L    | Theory of Statistics Lab | 0 + 4                      | 2.0     |

**Rationale of the Course:** Apply acquired knowledge of inferential statistics to analyze data.

#### Objectives

- Learn introductory statistical techniques and their applications,
- Capable to analyze, present and interpret data and results.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Perform analysis and interpret results in different fields of study;
- CLO2 Conduct statistical tests of hypotheses for one sample and interpret parameters;
- CLO3 Conduct statistical tests of hypotheses for two independent samples and interpret parameters;
- CLO4 Conduct statistical tests of hypotheses for two correlated samples and interpret parameters;
- CLO5 Conduct statistical tests of hypotheses for several samples and interpret parameters;
- CLO6 Conduct statistical tests of hypotheses for correlation coefficients and interpret parameters;
- CLO7 Conduct statistical tests of hypotheses for regression coefficients and interpret parameters;
- CLO8 Conduct statistical tests of hypotheses for association of attributes.

#### Mapping CLOs to PLOs

| CLO/PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1    |       |       | ✓     | ✓     | ✓     |       | ✓     | ✓     |       | ✓      |

|      |  |  |   |   |   |  |   |   |  |   |
|------|--|--|---|---|---|--|---|---|--|---|
| CLO2 |  |  | ✓ | ✓ | ✓ |  | ✓ | ✓ |  | ✓ |
| CLO3 |  |  | ✓ | ✓ | ✓ |  | ✓ | ✓ |  | ✓ |
| CLO4 |  |  | ✓ | ✓ | ✓ |  | ✓ | ✓ |  | ✓ |
| CLO5 |  |  | ✓ | ✓ | ✓ |  | ✓ | ✓ |  | ✓ |
| CLO6 |  |  | ✓ | ✓ | ✓ |  | ✓ | ✓ |  | ✓ |
| CLO7 |  |  | ✓ | ✓ | ✓ |  | ✓ | ✓ |  | ✓ |
| CLO8 |  |  | ✓ | ✓ | ✓ |  | ✓ | ✓ |  | ✓ |

#### Contents of the Course

Small and large sample tests for proportion, mean, variance, correlation coefficient, regression coefficient, test for independence in contingency table.

#### Main Texts

1. Mood A., Graybill F., Boes D., (1974), Introduction to the Theory of Statistics, 3<sup>rd</sup> Edition, McGraw Hill, NY
2. Hogg R. V., McKean J., & Craig A. T., (2012), Introduction to Mathematical Statistics, 7<sup>th</sup> Edition, Pearson

#### Reference Books

1. Ali M. A., (1973), Theory of Statistics, Vol-II, Dhaka Book Mart
2. David H A, Nagaraja H N (2003), Order Statistics, 3<sup>rd</sup> Edition, Wiley, NY
3. Gupta S. C. & Kapoor V. K., (2000), Fundamentals of Mathematical Statistics, 10<sup>th</sup> Edition, Sultan Chand and Sons, New Delhi, India

| Year                 | Semester                 | Course No. | Course Title                               | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 1 <sup>st</sup> Semester | MAT207O    | Advanced Calculus & Differential Equations | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on advanced calculus and differential equations.

#### Objectives

- To understand elementary analytical solution techniques for the solution of ordinary differential equations (ODEs),
- To provide the knowledge of linear ODEs in terms of independent homogeneous and non-homogeneous solutions,
- Make the students understand series, including convergence properties and use in representing functions,
- To develop skills on the use of approximation in studying mathematical and scientific problems and the importance of accuracy of approximations.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Improve problem-solving skills, including knowledge of techniques for the solution of ODEs;
- CLO2 Learn the importance of differential equations in the sciences and engineering;
- CLO3 Improve logical thinking and problem-solving skills;

- CLO4 Apply differential equations in the growth model;  
 CLO5 Determine maximum or minimum value for a function of several variables subject to a given constraint;  
 CLO6 Use integration techniques in finding the consumer's surplus, producer's surplus, and exponential growth and decay;  
 CLO7 Solve linear and non-linear differential equations;  
 CLO8 Solve system of two linear equations and find eigenvalues.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          |          |          |          | √        |          |          |          |           |
| CLO2        | √        |          |          |          |          | √        |          |          |          |           |
| CLO3        | √        |          |          |          |          | √        |          |          |          |           |
| CLO4        | √        |          |          |          |          | √        |          |          |          |           |
| CLO5        | √        |          |          |          |          | √        |          |          |          |           |
| CLO6        | √        |          |          |          |          | √        |          |          |          |           |
| CLO7        | √        |          |          |          |          | √        |          |          |          |           |
| CLO8        | √        |          |          |          |          | √        |          |          |          |           |

#### Contents of the Course

Advanced Calculus: Improper integrals; Gamma and Beta functions; their incompleteness and other properties; functions of several variables and limit and continuity; Taylor's expansion of such functions; maxima and minima of functions of more than one variable; Lagrange's multipliers; multiple integrals; Jacobians of transformation; Dirichlet integral and its extension; Laplace transformation; concept of Fourier series, inverse Laplace transformation, Lotka-Volterra integral equation, convolution theorem. Differential Equations: Definition; solution of differential equations; basic theory of linear differential equations; basic theory of non-linear differential equations; equations of the first order and their solution; homogeneous differential equations; linear differential equations of the second and higher order and their solution, system of differential equations.

#### Reference Books

- Anton H., Bivens I. & Davis S., (2012), Calculus Early Transcendentals, 10<sup>th</sup> Edition, John Wiley & Sons Inc
- Thomas G. B., Finney R. L., (1995), Calculus and Analytic Geometry, 9<sup>th</sup> Edition, Addison Wesley
- Wrede R., Spiegel M., (2010), Advanced Calculus, 3<sup>rd</sup> Edition, Schaum's Outlines Series, McGraw-Hill Education
- Widder D. V., (2012), Advanced Calculus, 2<sup>nd</sup> Edition, Dover Publications
- Ross S. L., (1985), Differential Equations, 3<sup>rd</sup> Edition, John Wiley & Sons, Inc
- Ayres F., Differential Equations, 3<sup>rd</sup> Edition, McGraw-Hill Education
- Sharma B. D., (2001), Differential Equations, Kedar Nath Ram Nath, India

| Year                    | Semester                    | Course No. | Course Title                    | Hours/Week<br>(Theory + Lab) | Credits |
|-------------------------|-----------------------------|------------|---------------------------------|------------------------------|---------|
| 2 <sup>nd</sup><br>Year | 1 <sup>st</sup><br>Semester | ECO2010    | Principles of<br>Microeconomics | 3 + 0                        | 3.0     |

**Rationale of the Course:** Acquiring knowledge on principles of Microeconomics.

#### Objectives

- To provide the basic knowledge on elementary concepts of Microeconomics,
- Make the students understand the idea of consumer and firm behaviors,
- Introduce students with different types of market structures (monopoly, oligopoly and competitive market),
- To facilitate necessary knowledge about economic principles to a range of policy questions.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Understand how decisions are made by the agents;  
 CLO2 Understand market equilibrium and price determination;  
 CLO3 Use the concept of elasticity quantitatively and qualitatively in economic analysis;  
 CLO4 Understand consumer optimum and price effect;  
 CLO5 Understand the production function & cost function and their long run and from short run; and  
 CLO6 Show differences between different types of markets.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        |          | √        |          | √        |          |          | √         |
| CLO2        | √        |          | √        |          | √        |          | √        |          |          | √         |
| CLO3        | √        |          | √        |          | √        |          | √        |          |          | √         |
| CLO4        | √        |          | √        |          | √        |          | √        |          |          | √         |
| CLO5        | √        |          | √        |          | √        |          | √        |          |          | √         |
| CLO6        | √        |          | √        |          | √        |          | √        |          |          | √         |

#### Contents of the Course

**Introduction:** Definition and scope of economics; Microeconomics vs. Macroeconomics; basic concepts of scarcity, choice, opportunity cost and efficiency with first basic model of PPF; fundamental economic problems and solution systems; economic method.

**Demand, Supply, and Market:** Concept of demand, supply and equilibrium; determinants of demand and supply; shifting of demand and supply curves; application of demand and supply;

**Elasticity of demand and supply:** Elasticity– Price elasticity of demand and supply and its determinants, income and cross elasticity, elasticity and revenue; application of elasticities.

**Theory of Consumers:** Concepts of utility; cardinal vs. ordinal utility; cardinal approach—law of diminishing marginal utility, paradox of value; ordinal approach—consumer's preference, indifference curve; properties of indifference curves; budget constraints; consumer's equilibrium.

**Theory of Firm:** Production function; law of diminishing return; stages of production; law of variable proportion; economic vs. accounting cost, short run and long run cost concepts with relevant numerical and graphical analysis.

**Theory of Profit:** Structure of markets; characteristics of different types of markets; perfect competition and monopoly-price and output determination, oligopoly, monopolistic competition.

#### Reference Books

1. Campbell, R. M., Stanley, L. B. and Sean, M. F. (2012): Microeconomics, McGraw-Hill Series in Economics, Twentieth edition.
2. Koutsoyiannis, A. (2003): Modern Microeconomics, Palgrave Macmillan, Second Revised Edition
3. Mankiw, N. G. (2014): Principles of Microeconomics, Thomson South Western Publishing, Seventh Edition
4. Parkin, M. (2013): Microeconomics, Pearson Series in Economics, 11th Edition.
5. Samuelson, P A and Nordhaus, W. D. (2009): Economics, McGraw-Hill USA, Nineteenth Edition.

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 1 <sup>st</sup> Semester | STA200A    | Presentation & Viva-voce | 0 + 0                     | 1.0     |

**Rationale of the course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

#### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Develop verbal communication and presentation skills;
- CLO2 Communicate their learning effectively and appropriately to formal audiences;
- CLO3 Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;
- CLO4 Prepare for professional oral examinations which is useful to enhance employment interview skills;
- CLO5 Demonstrate their ability to participate in academic discussion.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO2        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO3        | √     | √     |       |       | √     |       |       | √     | √     | √      |

|      |   |   |  |  |   |  |  |   |   |   |
|------|---|---|--|--|---|--|--|---|---|---|
| CLO4 | √ | √ |  |  | √ |  |  | √ | √ | √ |
| CLO5 | √ | √ |  |  | √ |  |  | √ | √ | √ |

**Contents of the Course:** Comprehensive contents of all the underlying courses of the semester.

#### Main Text

- Textbooks referred for all the underlying courses of the semester.

#### Reference Books

- Reference books referred for all the underlying courses of the semester.

#### Second Year Second Semester Course Details

| Year                 | Semester                 | Course No. | Course Title            | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 2 <sup>nd</sup> Semester | STA252     | Regression Analysis – I | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on the fundamental concepts of regression analysis.

#### Objectives

- Familiarize students with the concepts of the statistical modeling,
- Helping students to develop ability in model fitting through estimation of parameters,
- To provide knowledge of assessing fitted model, testing relevant hypotheses and perform forecasting,
- Acquaint students with basic tools of regression models, techniques and interpretations to use in practice.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Understand the type and extent of relationships among variables;
- CLO2 Formulate regression model with underlying assumptions involved;
- CLO3 Estimate parameters, evaluate model fit and assess adequacy of the model;
- CLO4 Revise regression models in case of violation of assumptions;
- CLO5 Apply suitable theories and models to the phenomena or systems in diverse sectors;
- CLO6 Point out the limitations of elementary tools and techniques of regression modeling.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       | √     | √     | √     |       |       | √      |
| CLO2        | √     |       | √     |       | √     | √     | √     |       |       | √      |
| CLO3        | √     |       | √     |       | √     | √     | √     |       |       | √      |
| CLO4        | √     |       | √     |       | √     | √     | √     |       |       | √      |
| CLO5        | √     |       | √     |       | √     | √     | √     |       |       | √      |
| CLO6        | √     |       |       |       | √     |       | √     |       |       | √      |

### Contents of the Course

**Correlation Analysis:** Basic idea of correlation and coefficient of correlation, rank correlation, spurious correlation, non-sense correlation.

**Other Techniques of Correlation:** Point-biserial and biserial correlations, Fourfold correlation, poly-choric correlation, and intra-class correlation.

**Simple Linear Regression:** The concept of population and sample regression functions, method of least squares, estimation of regression coefficients, OLS estimators, and correlation ratio.

**Topics on Estimation and Hypothesis Testing:** The classical linear regression model, Gauss-Markov theorem, estimation of error variance, hypothesis testing.

**Bivariate Quantitative Data:** Regression curves from bivariate distributions, bivariate normal distribution, marginal distribution, conditional distribution.

**Multiple Linear Regression:** Regression through the origin, scaling and units of measures, different functional forms of regression models.

Three variable regression, estimation of parameters and standard error, separation of effects, multiple and partial correlation, concepts of polynomial regression.

**Residual Analysis:** Basic concepts, analysis of residuals by graphs, lack of fit of model adequacy.

### Main Texts

1. Montgomery D. C., Peck E. A., Vining G. G., (2012), Introduction to Linear Regression Analysis, 5<sup>th</sup> Edition, John Wiley, NY
2. Gujarati, D. N. (2009), Basic econometrics: Tata McGraw-Hill Education
3. Draper N. R. & Smith H., (1998), Applied Linear Regression, 3<sup>rd</sup> Edition, John Wiley, NY

### Reference Books

1. Chatterjee S & Price P, Regression Analysis by Example, John Wiley, NY
2. Graybill F A, An Introduction to Linear Statistical Models, Vol-1, McGraw Hill, NY
3. Griffiths W E, et al, Learning and Practicing Econometrics, John Wiley & Sons, NY
4. Johnston, J., & Di Nardo, J. (2007). Econometric Methods-University of California, Irvine: The McGraw-Hill Companies, Inc.
5. Judge G G, *et al*, The Theory and Practice of Econometrics, 2<sup>nd</sup> Edition, John Wiley & Sons, NY
6. Koutsoyiannis, A. (1979). Theory of Econometrics, The Macmillan Press Ltd, London.
7. Seber G A F, General Linear Regression Analysis, Wiley & Sons Ltd, NY
8. Weisberg S, Applied Linear Regression, 2<sup>nd</sup> Edition, John Wiley, NY

| Year                 | Semester                 | Course No. | Course Title                | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 2 <sup>nd</sup> Semester | STA252L    | Regression Analysis – I Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge to solve practical problems based on the theory learnt.

### Objectives

- Demonstrate students how to use correlation theory to measure the strength of relationships among random phenomena,
- Equip students with the tools and techniques to use regression models in practice.

**Course Learning Outcomes:** At the end of course, students will be able to –

CLO1 Measure the strength of relationships among random variables;

CLO2 Estimate model parameters;

CLO3 Evaluate model fit

CLO4 Assess adequacy of the model;

CLO5 Find the best fitted regression equation to predict the mean value of a dependent variable;

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        |          |          |          | √        |          |          | √         |
| CLO2        | √        |          | √        |          |          |          | √        |          |          | √         |
| CLO3        | √        |          | √        |          |          |          | √        |          |          | √         |
| CLO4        | √        |          | √        |          |          |          | √        |          |          | √         |
| CLO5        | √        |          | √        |          |          |          | √        |          |          | √         |

### Contents of the Course

Correlation coefficient, rank correlation, biserial correlation, poly-choric correlation, and intra-class correlation.

**Simple Linear Regression:** OLS estimators, correlation ratio, hypothesis testing, regression through the origin, scaling and units of measures.

**Multiple Linear Regression:** Estimation of parameters and standard error, separation of effects, multiple and partial correlation.

**Model Adequacy:** Analyses of residuals by graphs, lack of fit.

### Main Texts

1. Montgomery D. C., Peck E. A., Vining G. G., (2012), Introduction to Linear Regression Analysis, 5<sup>th</sup> Edition, John Wiley, NY
2. Gujarati, D. N., (2009), Basic econometrics: Tata McGraw-Hill Education
3. Draper N. R. & Smith H., (1998), Applied Linear Regression, 3<sup>rd</sup> Edition, John Wiley, NY

### Reference Books

1. Chatterjee S. & Price P, Regression Analysis by Example, John Wiley, NY
2. Griffiths W E, et al, Learning and Practicing Econometrics, John Wiley & Sons, NY
3. Koutsoyiannis, A., (1979), Theory of Econometrics, The Macmillan Press Ltd, London.
4. Weisberg S, Applied Linear Regression, 2<sup>nd</sup> Edition, John Wiley, NY

| Year                 | Semester                 | Course No. | Course Title      | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 2 <sup>nd</sup> Semester | MAT208O    | Numerical Methods | 2 + 0                     | 2.0     |

**Rationale of the Course:** Acquire knowledge on numerical algorithms.

#### Objectives

- Provide knowledge on numerical methods to solve algebraic and transcendental equations,
- To facilitate necessary knowledge on different methods of interpolations and extrapolations,
- Helping the students to apply appropriate numerical methods to solve differential equations and to calculate definite integrals,
- Help students conceptualize the ideas about various numerical root finding methods,
- To equip the students with various methods of convergence and understand the errors,
- To facilitate necessary knowledge about explaining and understanding of methods to solve the simultaneous equations.

**Course Learning Outcomes:** At the end of the course, students will be able to –

CLO1 Understand theories and concepts used in numerical analysis;

CLO2 Perform numerical differentiation and numerical integration;

CLO3 Demonstrate solid understanding on convergence and errors in approximations;

CLO4 Learn to solve systems of simultaneous linear equations;

CLO5 Apply Newton-Raphson method to find roots of single variable equation.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO2        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO3        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO4        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO5        | √     |       | √     |       |       |       | √     |       |       |        |

#### Contents of the Course

Numerical methods: interpolation and extrapolation; shifting operators; difference operators and their relationships; Newton's interpolation formulae; Lagrange's formula; Newton's divided difference formula; central difference formulae (Stirling and Bessel's); relationship between divided difference and simple difference.; inverse interpolation formula; numerical differentiation; numerical integration by Trapezoidal rule, Simpson's 1/3 and 3/8 rules, Weddle's rule; convergence of these methods and their inherent errors; numerical solution of simultaneous linear equation; solution by determinants, by inverse matrices, by iteration and by successive elimination of the unknowns, Newton-Raphson method.

#### Main Text

- Scarborough J. B., (2017), Numerical Mathematical Analysis, 6<sup>th</sup> Edition, Oxford & IBH, New Delhi

#### Reference Books

1. Freeman H, Finite Difference for Actuarial Students, 2<sup>nd</sup> Edition, Cambridge University Press, UK
2. Noble B, Numerical Methods, Vol. I and II

| Year                 | Semester                 | Course No. | Course Title  | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|---------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 2 <sup>nd</sup> Semester | MAT209O    | Real Analysis | 2 + 0                     | 2.0     |

**Rationale of the Course:** Acquiring knowledge on real analysis.

#### Objectives

- To provide the knowledge of real number system,
- Help the students to understand the idea of sequences and infinite series,
- To facilitate necessary knowledge on limit and continuity,
- Help the students to develop skills on derivatives and Riemann integration.

**Course Learning Outcomes:** At the end of the course, students will be able to –

CLO1 Describe the fundamental properties of the real numbers that underpin the formal development of real analysis;

CLO2 Demonstrate an understanding of the theory of sequences and series

CLO3 Learn limit and continuity;

CLO4 Evaluate differentiation and integration;

CLO5 Apply skills in constructing rigorous mathematical arguments.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO2        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO3        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO4        | √     |       | √     |       |       |       | √     |       |       |        |
| CLO5        | √     |       | √     |       |       |       | √     |       |       |        |

#### Contents of the Course

**Real number system:** Neighborhoods, Open and Closed sets, Bounded sets, Interior point of a set, Limit point of a set, Supremum and infimum, Completeness.

**Sequences:** Bounded sequence, Convergent sequence, Monotonic sequence, Cauchy sequence.

**Infinite series:** Convergent series, Positive term series, Tests for convergence, e.g., comparison test, limit comparison test, ratio comparison test etc.

**Limit and continuity:** Limits of functions, Infinite limits, Limits at infinity, Continuous and discontinuous functions, Properties of continuous functions; Uniform continuity.

**Derivatives:** Differentiability of functions, Rolle's theorem, Mean value theorem and applications, Taylor's theorem with remainder in Lagrange's forms.

**Riemann integration:** Riemann integral, Criterion for integrability, Certain classes of integrable functions, Fundamental theorem of integral calculus.

### Main Texts

1. Chatterjee P. N., (1995), Real Analysis, Rajhans Prakashan Mandir, Meerut, India
2. Chowdhury F. & Chowdhury M. R., (2010), Essentials of Real Analysis, Pi Publications, Dhaka
3. Rudin W., (1976), Principles of Mathematical Analysis, McGraw-Hill Book Company

### Reference Books

1. Bartle R. G. & Sherbert D. R., (2011), Introduction to Real Analysis, John Wiley & Sons Inc
2. Davidson K. R. & Donsig A. P., (2002), Real Analysis with Real Applications, Prentice Hall Inc
3. Malik S. C. & Arora S., (2009), Mathematical Analysis, New Academic Science Ltd, United Kingdom
4. Mapa S. K., (2006), Introduction to Real Analysis, Sharat Book Distributor, Kolkata, India
5. Trench W. F., (2011), Introduction to Real Analysis, Trinity University San Antonio, Texas, USA

| Year                 | Semester                 | Course No. | Course Title                 | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|------------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 2 <sup>nd</sup> Semester | ECO2020    | Principles of Macroeconomics | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on macroeconomic study.

### Objectives

- Accumulate basic ideas about macroeconomic study,
- Make the students understand the national product, national income and investment,
- To understand basic knowledge on money, banking and monetary system,
- Getting idea about taxes, government expenditure, budget and fiscal policy,
- Make the students understand inflation, unemployment and international trade,

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Solve for equilibrium outcomes in simple models of the Macroeconomics and analyze how the predictions for aggregate macroeconomic variables are affected by micro behavior of individual agents and by other restrictions imposed on the equilibrium (such as financial frictions);
- CLO2 Distinguish between the classical and the Keynesian approaches to the study of Macroeconomics.
- CLO3 Assess the predictions of macroeconomic theories and compare them to data;
- CLO4 Value macroeconomic policies with the use of the model(s) introduced and developed throughout the course;
- CLO5 Theorize how unconventional monetary policy works under certain

economic or financial conditions;

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO2        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO3        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO4        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO5        | √        |          | √        |          | √        |          | √        | √        |          | √         |

### Contents of the Course

**Introduction to Macroeconomics:** Circular Flow Model and Components of Macroeconomics; Key Macroeconomic Performance Indicators: GDP, GNI, NI and Personal disposable income; Various Methods of GDP Measurement & their Shortcomings; Real vs. Nominal GDP; Growth Rate and Business Cycle.

**Determination of National Income:** Psychological law of Consumption, Consumption function, Saving & Investment Function, Government & External Sector functions; Leakages & Injections; Equilibrium Output & Multiplier; the Paradox of Thrift.

**AD-AS Model:** Aggregate Demand Curve-Definition, Shape & Determinants; Aggregate Supply Curve-Definition, Shape and Determinants, Classical vs. Keynesian views on AS Curves; Macro-Equilibrium using AD-AS.

**Inflation and Unemployment:** Definitions & Types of Inflation; Price Indices—GDP Deflator & CPI; Demand pull and Cost push inflation; Benefits & Costs of Inflation; Definitions and causes of unemployment, remedial measures, Phillips Curve.

**Money and Banking:** Definition & functions of money, components of money supply and money demand, multiple deposit creation, commercial banks & the money stock; functions of central bank, types and instruments of monetary policy.

**Budget and Fiscal Policy:** Definition, Objectives, Types and instruments of Fiscal policy; Budget, types of taxation; heads of government expenditure.

### Reference Books

1. Arnold, R. A. (2014): Economics, South Western Publishing Company, Eleventh Edition
2. Baumol, W. J. and Blinder, A. S. (2009): Macroeconomics, South-Western Cengage Learning, Eleventh Edition.
3. Dornbusch, Rudiger, et al (2011): Macroeconomics, McGraw-Hill International, Eleventh Edition
4. Mankiw, G. (2012): Principles of Economics, Thomson South Western Publishing, Sixth Edition
5. Samuelson, P. A. and Nordhaus, W. D. (2009): Economics, McGraw-Hill USA, Nineteenth Edition.

| Year                 | Semester                 | Course No. | Course Title                        | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-------------------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 2 <sup>nd</sup> Semester | CSE2050    | Database Management and Programming | 2 + 0                     | 2.0     |

**Rationale of Course:** Acquiring basic concepts of database management system and its programming.

### Objectives

- Provide necessary knowledge on the issues involved in the design and implementation of a database system,
- Helping the students to understand the physical and logical database designs, database modeling, relational, hierarchical and network models,
- Make the students understand the data manipulation language to query, update, and manage a database,
- Helping the students to understand essential DBMS concepts such as: database security, integrity, concurrency, distributed database, Client/Server (Database Server), Data Warehousing,
- To develop skills on design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing and implementing a DBMS.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 - Describe the fundamentals of database systems;  
 CLO2 - Differentiate between different database models;  
 CLO3 - Design a relational database;  
 CLO4 - Create queries in relational databases;  
 CLO5 - Use indexing for databases;  
 CLO6 - Implement concurrency control mechanisms.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO2        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO3        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO4        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO5        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO6        | √        |          | √        | √        | √        | √        | √        |          |          | √         |

### Contents of the Course

**Computer Basics:** Concept on Computer Hardware, Software and its classification, networking and Internet.

**Introduction to Database:** Database management system, relational database management system, entity-relationship model, relational model, SQL, sorting, indexing, integrity constraints, transaction concept, database system architecture.

**Database Management:** Creating a database, opening a database, modifying a database, modifying a database structure, indexing, sorting, searching a database, designing a customer screen, designing a report, designing a menu.

**Database Programming:** Programming concept, a simple program, memory variables, constants, operators, commands, arrays, macros, different type of processing, procedures, functions. programming for data entries, update, report, menu and searching.

### Main Texts

1. Korth H. F., Sudarshan S., Silberschatz A., (2010), Database System Concepts, McGraw-Hill Education
2. Elmasri R. & Navathe S. B., (2009), Fundamentals of Database Systems, 5<sup>th</sup> Edition, Pearson Education India

### Reference Book

- Ramakrishnan, R., Gehrke, J., & Gehrke, J. (2003), Database management systems, Vol. 3, McGraw-Hill, NY

| Year                 | Semester                 | Course No. | Course Title                            | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------------------------|---------------------------|---------|
| 2 <sup>nd</sup> Year | 2 <sup>nd</sup> Semester | CSE206O    | Database Management and Programming Lab | 6 + 0                     | 3.0     |

**Rationale of the Course:** Apply acquired knowledge to design and implement database system and SQL.

### Objectives

- Make the students understand the Windows operating system, word processor, electronic spreadsheet, and presentation software,
- Helping the students to create, modify, indexing, sorting a database, design a customer screen, design a report, designing a menu,
- Helping students to write database programming.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Apply functions to process numeric data  
 CLO2 - Use SQL query to grouping data.  
 CLO3 - Apply DDL to insert, update and manage database schema  
 CLO4 - Design a Relational Database  
 CLO5 - Use indexing for databases  
 CLO6 - Use Nested sub queries, complex queries  
 CLO7 - Maintain integrity and consistency of data

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO2        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO3        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO4        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO5        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO6        | √        |          | √        | √        | √        | √        | √        |          |          | √         |
| CLO7        | √        |          | √        | √        | √        | √        | √        |          |          | √         |

### Contents of the Course

Basic concepts of Windows operating system, Word Processor software, SpreadSheet software, and Presentation software. Database Management: Create, modify, indexing, sorting a database, Designing a customer Screen, designing a report, designing a menu. Database Programming: SQL, Basic structure of SQL

Queries, Query-by-example, Nested sub queries, Complex queries, Integrity constraints, Authorization.

#### Main Texts

1. Korth H. F., Sudarshan S., Silberschatz A., (2010), Database System Concepts, McGraw-Hill Education
2. Elmasri R. & Navathe S. B., (2009), Fundamentals of Database Systems, 5<sup>th</sup> Edition, Pearson Education India

#### Reference Book

- Ramakrishnan, R., Gehrke, J., & Gehrke, J. (2003), Database management systems, Vol. 3, McGraw-Hill, NY

| Year                    | Semester                    | Course No. | Course Title                | Hours/Week<br>(Theory + Lab) | Credits |
|-------------------------|-----------------------------|------------|-----------------------------|------------------------------|---------|
| 2 <sup>nd</sup><br>Year | 2 <sup>nd</sup><br>Semester | STA200B    | Presentation &<br>Viva-voce | 0 + 0                        | 1.0     |

**Rationale of the Course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

#### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Develop verbal communication and presentation skills;
- CLO2 Communicate their learning effectively and appropriately to formal audiences;
- CLO3 Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;
- CLO4 Prepare for professional oral examinations which is useful to enhance employment interview skills;
- CLO5 Demonstrate their ability to participate in academic discussion.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO2        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO3        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO4        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO5        | √        | √        |          |          | √        |          |          | √        | √        | √         |

**Contents of the Course:** Comprehensive contents of all the underlying courses of the semester.

#### Main Text

- Textbooks referred for all the underlying courses of the semester.

#### Reference Books

- Reference books referred for all the underlying courses of the semester.

#### Third Year First Semester Course Details

| Year                    | Semester                    | Course No. | Course Title                                 | Hours/Week<br>(Theory + Lab) | Credits |
|-------------------------|-----------------------------|------------|----------------------------------------------|------------------------------|---------|
| 3 <sup>rd</sup><br>Year | 1 <sup>st</sup><br>Semester | STA351     | Design and<br>Analysis of<br>Experiments – I | 3 + 0                        | 3.0     |

**Rationale of the Course:** Acquiring knowledge on designing experiments and analyzing the experimental data.

#### Objectives

- Acquaint students with the issues and principles of design of experiments,
- Make students understand the concepts of basic ideas and principles of analysis of variance,
- To facilitate necessary knowledge about experimental errors and the way to control them,
- Help students develop ability to analyze single factor design of experiments,
- Foster the analytical ability to thoroughly study and analyze factorial design of experiments.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Explain methods of ANOVA;
- CLO2 - Compare variations between groups;
- CLO3 - Discriminate the within group and between group variability;
- CLO4 - Prepare design and analyze data from single factor experiments;
- CLO5 - Layout design and analyze factorial experiments;
- CLO6 - Evaluate adequacy of models for single factor and factorial experiments.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        | √        | √        | √        |          | √        | √        |          | √         |
| CLO2        | √        |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO3        | √        |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO4        | √        | √        | √        | √        | √        |          | √        | √        |          | √         |
| CLO5        | √        |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO6        | √        |          | √        | √        | √        |          | √        | √        |          | √         |

#### Contents of the Course

Basic ideas of analysis of variance, One-way classification with equal and unequal observations, Two-way and three-way classification with single and multiple observations per cell, Experimental errors and their control, Analysis of variance with fixed effect, random effect and mixed effect models, Model adequacy checking.

**Multiple comparison:** Introduction, Tukey's W-test, Newman-Keuls several range test, Duncan multiple range test, Dunnett's test, Bonferroni test.

**Experimental designs:** Introduction, Principles of experimental design, uniformity trial, choice of size and shape of plots and blocks, estimation and analysis of completely randomized design, randomized block design and Latin square design. Orthogonality of designs, Analysis of replicated Latin square design, Graceo-Latin square design.

**Factorial Experiment:** Introduction to factorial design, factorial experiment for two or three levels up to n factors.

### Main Texts

1. Montgomery D C, (2020), Design and Analysis of Experiments, 10<sup>th</sup> Edition, Wiley, NY
2. Das M. N. & Giri N. C., (2017), Design and Analysis of Experiments, 3<sup>rd</sup> Edition, New Age International, Delhi
3. Sahai H. & Ageel, M. I., (2000), The Analysis of Variance: Fixed. Random and Mixed Models, MA: Birkhauser, Boston

### Reference Books

1. Bhuyan M R, Fundamentals of Experimental Design, 2<sup>nd</sup> Edition, Book World Publications, Dhaka
2. Cochran W G & Cox D R, Experimental Design, 2<sup>nd</sup> Edition, John Wiley & Sons, NY
3. Davis O L, Design and Analysis of Industrial Experiments, Oliver & Boyd, London
4. Federer W T, Experimental Design: Theory and Application, Oxford & IBH Publishing Company, NY
5. Gomez K A & Gomez A A, Statistical Procedures for Agricultural Research, 2<sup>nd</sup> Edition, Wiley, NY
6. Sheffe H, The Analysis of Variance, John Wiley & Sons, NY
7. Winer B J, Statistical Principles in Experimental Design, 2<sup>nd</sup> Ed., McGraw Hill Company, Ltd

| Year                 | Semester                 | Course No. | Course Title                               | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 1 <sup>st</sup> Semester | STA351L    | Design and Analysis of Experiments – I Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge for solving the problems on design of experiments.

### Objectives

- Help the students to detect experimental errors and control them,
- Acquaint students with the methods of conducting single factor design of experiments,
- Helping the students to develop ability to perform factorial design of experiments.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Calculate ANOVA for one-way and two-way classified data;

CLO2 - Test the equality of treatment means;

CLO3 - Determine the within group and between group variability;

CLO4 - Analyze single factor experiments;

CLO5 - Analyze factorial experiments.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       |       | √     | √     | √     |       | √     | √     |       | √      |
| CLO2        |       |       | √     | √     | √     |       | √     | √     |       | √      |
| CLO3        |       |       | √     | √     | √     |       | √     | √     |       | √      |
| CLO4        |       |       | √     | √     | √     |       | √     | √     |       | √      |
| CLO5        |       |       | √     | √     | √     |       | √     | √     |       | √      |

### Contents of the Course

One-way classification with equal and unequal observations, Two-way and three-way classification with equal number of observations per cell, Experimental error and interpretation of data, Analysis of variance with fixed effect, random effect and mixed effect models, Model adequacy checking.

**Multiple comparison:** Tukey's W-test, Newman-Keuls several range test, Duncan multiple range test, Dunnett's test, Bonferroni test.

**Experimental designs:** Estimation and analysis of completely randomized design, randomized block design and Latin square design.

**Orthogonality of designs:** Dealing with missing data in experimental design.

**Factorial Experiment:** Analysis of factorial experiments for two and three levels.

### Main Texts

1. Montgomery D. C., (2020), Design and Analysis of Experiments, 10<sup>th</sup> Edition, Wiley, NY
2. Das M. N. & Giri N. C., (2017), Design and Analysis of Experiments, 3<sup>rd</sup> Edition, New Age International, Delhi
3. Sahai H. & Ageel M. I., (2000), The Analysis of Variance: Fixed. Random and Mixed Models, MA: Birkhauser, Boston

### Reference Books

1. Bhuyan M R, Fundamentals of Experimental Design, 2<sup>nd</sup> Edition, Book World Publications, Dhaka
2. Davis O L, Design and Analysis of Industrial Experiments, Oliver & Boyd, London
3. Federer W T, Experimental Design: Theory and Application, Oxford & IBH Publishing Company, NY
4. Gomez K A & Gomez A A, Statistical Procedures for Agricultural Research, 2<sup>nd</sup> Edition, Wiley, NY
5. Sheffe H, The Analysis of Variance, John Wiley & Sons, NY
6. Winer B J, Statistical Principles in Experimental Design, 2<sup>nd</sup> Ed., McGraw Hill Company, Ltd

| Year | Semester | Course No. | Course Title | Hours/Week (Theory + Lab) | Credits |
|------|----------|------------|--------------|---------------------------|---------|
|------|----------|------------|--------------|---------------------------|---------|

|                         |                             |        |                          |       |     |
|-------------------------|-----------------------------|--------|--------------------------|-------|-----|
| 3 <sup>rd</sup><br>Year | 1 <sup>st</sup><br>Semester | STA353 | Statistical<br>Inference | 3 + 0 | 3.0 |
|-------------------------|-----------------------------|--------|--------------------------|-------|-----|

**Rationale of the Course:** Acquiring knowledge on methods of estimation and tests of hypotheses.

#### Objectives

- Facilitate necessary knowledge about the techniques for estimating the population parameters,
- Make students understand the properties of point estimates,
- Acquaint students with the basic concepts of interval estimates,
- Help students understand the basic concepts of hypotheses testing using both parametric and non-parametric approaches.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Explain the components and approach of statistical inferences;

CLO2 - Estimate the parameters using different techniques of point estimation;

CLO3 - Identify the best point estimators;

CLO4 - Construct interval estimation of the parameters using different techniques;

CLO5 - Develop the criteria for testing the hypotheses of the statements of population using sample observations;

CLO6 - Differentiate between parametric and non-parametric tests of hypotheses and employ the appropriate technique on a given data set.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        | √        | √        |          | √        |          |          |           |
| CLO2        | √        |          | √        | √        | √        |          | √        |          |          |           |
| CLO3        | √        |          | √        | √        | √        |          | √        |          |          |           |
| CLO4        | √        |          | √        | √        | √        |          | √        |          |          |           |
| CLO5        | √        |          | √        | √        | √        |          | √        |          |          |           |
| CLO6        | √        |          | √        | √        | √        |          | √        |          |          |           |

#### Contents of the Course

Point estimation: basic concepts, principles of point estimation. Method of point estimation: method of maximum likelihood, method of moments, method of least squares, method of minimum chi-squares, method of minimum variance, and Bayes' method. Properties of point estimators: unbiasedness, sufficiency, consistency, efficiency, asymptotic efficiency. Cramer-Rao lower bound, MVB estimate. Interval estimation: concept of central and non-central confidence interval. Confidence interval for parameters of normal, binomial and Poisson distributions, large sample confidence interval.

Parametric tests: review of basic concepts, simple hypothesis & composite hypothesis, Type I error, Type II error, size and power of the test, critical region. Best critical region, Neyman-Pearson fundamental lemma, most powerful tests, uniformly most powerful critical region, UMP tests.

Non-parametric tests: tests based on runs, tests of goodness of fit. Rank order statistics. Other one sample and paired sample techniques. The sign test and signed

rank test. The general two sample problem. Linear rank statistics and the general two-sample problem. Linear rank tests for the location problem, linear rank tests for the scale problem. Tests of the equality of k independent samples. Measures for bivariate samples. Measures of association in multiple comparison.

#### Main Texts

- Casella G. & Berger R. L., (1990), Statistical Inference, 2<sup>nd</sup> Edition, Duxbury Thomson Learning, USA
- Mood A., Graybill F., Boes D., (1974), Introduction to the Theory of Statistics, 3<sup>rd</sup> Edition, McGraw Hill, NY

#### Reference Books

- Beaumont W., Intermediate Mathematical Statistics, 2<sup>nd</sup> Edition, Cambridge University Press, London
- Cox D. R. & Hinkley D. V., Theoretical Statistics, Chapman and Hall, London
- Graybill F. A., Introduction to Linear Statistical Models, McGraw Hill, NY
- Hogg R. V. & Craig A. T., Introduction to Mathematical Statistics, Macmillan, NY
- Hollander M. & Wolf D. A., Nonparametric Statistical Methods, 2<sup>nd</sup> Edition, John Wiley & Sons, Inc, NY
- Kendall M. G. & Stuart A., The Advance Theory of Statistics, Vol-2, 4th Edition, Charles-Griffin, London
- Lindley D. V., The Use of Prior Probability Distributions in Statistical Inference and Decisions, Proceedings of the Fourth Berkeley Symposium on Mathematical Statistics and Probability, Vol 1
- Zacks S., Theory of Statistical Inference, John Wiley, NY

| Year                    | Semester                    | Course<br>No. | Course Title                 | Hours/Week<br>(Theory + Lab) | Credits |
|-------------------------|-----------------------------|---------------|------------------------------|------------------------------|---------|
| 3 <sup>rd</sup><br>Year | 1 <sup>st</sup><br>Semester | STA353L       | Statistical<br>Inference Lab | 0 + 4                        | 2.0     |

**Rationale of the Course:** Apply acquired knowledge on methods of estimation and tests of hypotheses.

#### Objectives

- Acquaint the students with the methods of point estimation,
- Familiarize the students with the techniques of interval estimation,
- Help the students to develop ability to perform hypothesis testing using real data.

**Course Learning Outcomes:** At the end of the course, students will be able to –

CLO1 Generate random sample from different distributions;

CLO2 Apply point estimation methods to estimate the parameters using the sample from different distributions;

CLO3 Construct interval estimation of the parameters using the sample from different distributions;

CLO4 Perform most powerful test and uniformly most powerful tests;

CLO5 Perform non-parametric tests.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          | √        | √        | √        | √        |          | √        | √        |          | √         |
| CLO2        |          |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO3        |          |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO4        |          |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO5        |          |          | √        | √        | √        |          | √        | √        |          | √         |

**Contents of the Course:** Drawing sample from univariate and bivariate normal distributions. Point estimation of parameters of univariate distributions by method of moments, method of maximum likelihood and method of least squares. Construction of confidence intervals for parameters of normal distribution, construction of large sample confidence interval for parameters of binomial and Poisson distribution. Tests of hypothesis regarding parameters of univariate and bivariate normal distributions, tests of hypothesis regarding parameters of discrete and continuous distributions. Calculation of best critical region and drawing power curve. Nonparametric tests. Other topics as covered in the theory part.

#### Main Texts

1. Hogg R V & Craig A T, Introduction to Mathematical Statistics, Macmillan, NY
2. Mood A., Graybill F., Boes D., (1974), Introduction to the Theory of Statistics, 3<sup>rd</sup> Edition, McGraw Hill, NY

#### Reference Books

1. Casella G. & Berger R. L., (1990), Statistical Inference, 2<sup>nd</sup> Edition, Duxbury Thomson Learning, USA
2. Beaumont W, Intermediate Mathematical Statistics ,2<sup>nd</sup> Edition, Cambridge University Press, London
3. Graybill F A, Introduction to Linear Statistical Models, McGraw Hill, NY
4. Hollander M & Wolf D A, Nonparametric Statistical Methods, 2<sup>nd</sup> Edition, John Wiley & Sons, Inc, NY
5. Zacks S, Theory of Statistical Inference, John Wiley, NY

| Year                 | Semester                 | Course No. | Course Title              | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|---------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 1 <sup>st</sup> Semester | STA355     | Statistical Computing – I | 2 + 0                     | 2.0     |

**Rationale of the Course:** Acquiring knowledge of computational methods and algorithms for commonly used statistical procedures.

#### Objectives

- Acquaint students with fundamental tools for computing in the practice of quantitative analytical methods,

- To provide knowledge of programming with C/Python, SPSS, STATA,
- Facilitate necessary knowledge about data wrangling and exploratory data analysis,
- Help the students to develop skills to apply probability distributions and simulations, regression and linear models,
- Foster analytical and critical thinking ability to visualize, summarize and explore large data sets.

**Course learning Outcomes:** At the end of course, students will be able to –

- CLO1 Install and configure software necessary for a statistical programming environment;
- CLO2 Apply generic programming language;
- CLO3 Create and open SPSS and STATA data sets;
- CLO4 Open any other formatted data set in SPSS and STATA;
- CLO5 Merge and split datasets;
- CLO6 Add new variables/ cases to a dataset;
- CLO7 Select subset from data set;
- CLO8 Solve statistical problems using, SPSS, STATA.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          |          |          |          |          |          |          | √        |          | √         |
| CLO2        |          |          |          | √        | √        | √        | √        |          |          | √         |
| CLO3        |          |          |          | √        | √        | √        | √        |          |          | √         |
| CLO4        |          |          |          | √        | √        | √        | √        |          |          | √         |
| CLO5        |          |          |          | √        | √        | √        | √        |          |          | √         |
| CLO6        |          |          |          | √        | √        | √        | √        |          |          | √         |
| CLO7        |          |          |          | √        | √        | √        | √        |          |          | √         |
| CLO8        | √        | √        | √        | √        | √        | √        | √        | √        |          | √         |

#### Contents of the Course

Introduction to Computers: Basic of MS Word, Excel and Power point. Data analysis in Excel.

Programming C and Python: introduction and basic structure of C and python programs. Sequential Structure: data types, arithmetic operations, expressions, assignment statements, input and output. Selective Structure: relational operators, logical operators, conditional Statements, repetitive structure, functions, arrays, application of programming in C and python for statistical computation.

Statistical packages – SPSS and STATA: data creation, manipulation and management (merge and matching); conditional statements including repetitive structure; and procedure commands for exploratory data analysis, graphical presentation, inferential analysis including regression, correlation, hypothesis tests, analysis of variance (ANOVA) and generalized linear model.

#### Main Texts

1. Frye C., (2018), Microsoft Excel 2019 Step by Step, 1<sup>st</sup> Edition, Microsoft Press, USA

- Gottfried B S, (2019), Theory and Problems of Programming with C, 3<sup>rd</sup> Edition, McGraw Hill, NY
- Lutz M., (2013), Learning Python, 5<sup>th</sup> Edition. O'Reilly Media, Inc.
- Lambert J., (2018), Microsoft PowerPoint 2019 Step by Step, 1<sup>st</sup> Edition, Microsoft Press, USA
- Lambert J., (2018), Microsoft Word 2019 Step by Step, 1<sup>st</sup> Edition, Microsoft Press, USA
- Hamilton L. C., (2012), Statistics with Stata, 12<sup>th</sup> Edition, STATA Bookstore
- George D. & Mallery P., (2016), IBM SPSS Statistics 23 Step by Step: A Simple Guide and Reference, 14<sup>th</sup> Edition, Routledge

#### Reference Books

- Mitchel M. N., A Visual Guide to Stata Graphics, 3<sup>rd</sup> Edition, STATA Bookstore
- Press W. H., *et al*, Numerical Recipes in C++: The Art of Scientific Computing, 2<sup>nd</sup> Edition, Cambridge University Press, UK
- Subin T. S., Computer Programming, C Programming, PDF Bangla Version, Bangladesh
- Matthes, E., (2019), Python crash course: a hands-on, project-based introduction to programming. No Starch Press.

| Year                 | Semester                 | Course No. | Course Title                  | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-------------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 1 <sup>st</sup> Semester | STA355L    | Statistical Computing – I Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge of computational methods and algorithms for commonly used statistical procedures.

#### Objectives

- Acquaint the students with the fundamental computing tools in quantitative analytical methods,
- Helping the students to use programming C, Python, SPSS, STATA,
- Facilitate necessary skills on data wrangling and exploratory data analysis,
- Helping the students to apply probability distributions and simulations, regression and linear models,

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Install and configure software necessary for a statistical programming environment;
- CLO2 Understand generic programming language;
- CLO3 Perform exploratory data analysis and statistical inference;
- CLO4 Merge and split datasets;
- CLO5 Add new variables/ cases to a dataset;
- CLO6 Select subset from data set;
- CLO7 Solve and interpret statistical problems using, SPSS, STATA.

#### Mapping CLOs to PLOs

| CLO/ | PLO | PLO | PLO | PLO | PLO | PLO | PLO | PLO | PLO | PLO |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|

| PLO  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------|---|---|---|---|---|---|---|---|---|----|
| CLO1 |   |   |   |   |   |   |   | √ |   | √  |
| CLO2 |   |   |   | √ | √ | √ | √ |   |   | √  |
| CLO3 |   |   |   | √ | √ | √ | √ |   |   | √  |
| CLO4 |   |   |   | √ | √ | √ | √ |   |   | √  |
| CLO5 |   |   |   | √ | √ | √ | √ |   |   | √  |
| CLO6 |   |   |   | √ | √ | √ | √ |   |   | √  |
| CLO7 | √ | √ | √ | √ | √ | √ | √ | √ |   | √  |

#### Contents of the Course

Calculation of different measures of central tendency, dispersion, skewness, kurtosis, correlation and regression. Factorials and binomial coefficients, summation of series, one dimensional function minimization. Statistical graphs using computer. Application of different statistical tools using C and Python, SPSS and STATA.

#### Main Texts

- Frye C., (2018), Microsoft Excel 2019 Step by Step, 1<sup>st</sup> Edition, Microsoft Press, USA
- Gottfried B. S., (2019), Theory and Problems of Programming with C, 3<sup>rd</sup> Edition, McGraw Hill, NY
- Lutz M., (2013), Learning Python, 5<sup>th</sup> Edition. O'Reilly Media, Inc.
- Lambert J., (2018), Microsoft PowerPoint 2019 Step by Step, 1<sup>st</sup> Edition, Microsoft Press, USA
- Lambert J., (2018), Microsoft Word 2019 Step by Step, 1<sup>st</sup> Edition, Microsoft Press, USA
- Hamilton L. C., (2012), Statistics with Stata, 12<sup>th</sup> Edition, STATA Bookstore
- George D. & Mallery P., (2016), IBM SPSS Statistics 23 Step by Step: A Simple Guide and Reference, 14<sup>th</sup> Edition, Routledge

#### Reference Books

- Mitchel M N, A Visual Guide to Stata Graphics, 3<sup>rd</sup> Edition, STATA Bookstore
- Press W H, *et al*, Numerical Recipes in C++: The Art of Scientific Computing, 2<sup>nd</sup> Edition, Cambridge University Press, UK
- Subin T S, Computer Programming, C Programming, PDF Bangla Version, Bangladesh
- Matthes, E., (2019), Python crash course: a hands-on, project-based introduction to programming. No Starch Press.

| Year                 | Semester                 | Course No. | Course Title       | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 1 <sup>st</sup> Semester | STA357     | Linear Programming | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge to learn methods for solving linear programming problems.

#### Objectives

- Foster analytical and critical thinking ability and provide ideas to formulate linear programming problem and theoretical knowledge of solving such type of problems by using appropriate methods,

- Helping the students to develop skills of modeling and optimization of various types (integer and non-integer) of linear programming problem,
- Facilitate necessary knowledge on analyzing the duality and sensitivity problems through different methods,
- Provide knowledge of various methods on game theory and transportation problem.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Explain the various terminology of linear programming problem;  
 CLO2 Formulate or construct linear programming problem;  
 CLO3 Compare and contrast various linear programming models;  
 CLO4 Identify appropriate methods to solve real life problem;  
 CLO5 Estimate the dual of a linear programming problem and hence find out primal solution of linear programming problem;  
 CLO6 Develop the criteria for catching up the sensitive change of studied data through minor correction of business strategies;  
 CLO7 Perform strategies of game theory;  
 CLO8 Apply the transportation simplex method to solve transportation problems.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        |          | √        |          | √        |          |          |           |
| CLO2        | √        |          | √        |          | √        |          | √        |          |          |           |
| CLO3        | √        |          | √        |          | √        |          | √        |          |          |           |
| CLO4        | √        |          | √        |          | √        |          | √        |          |          |           |
| CLO5        | √        |          | √        |          | √        |          | √        |          |          |           |
| CLO6        | √        |          | √        |          | √        |          | √        |          |          |           |
| CLO7        | √        |          | √        |          | √        |          | √        |          |          |           |
| CLO8        | √        |          | √        |          | √        |          | √        |          |          |           |

#### Contents of the Course

Elements of linear programming: formulation of linear programming problems, theorems of linear programming.

Methods of solution: graphical method, simplex method, revised simplex method, primal-dual problems and their solutions, degeneracy and cyclical problems, sensitivity analysis.

Integer linear programming: problem formulation, methods of solution, cutting plane algorithm, branch and bound algorithm, transportation problem and its solutions. Decision theory.

Game theory: two-person zero sum games. Equivalence of two-person zero sum game and a linear programming problem, methods of solution of the game problems.

#### Main Texts

1. Bazaraa M. S., Jarvis J. J., Sherali H. D., (2009), Linear programming and Network flows, 4<sup>th</sup> Edition, Wiley
2. Taha H. A., (2010), Introduction to Operation Research, 9<sup>th</sup> Edition, Pearson

#### Reference Books

1. Charnes V. & Kumar M., Data Envelopment Analysis and Its Applications to Management, Cambridge Scholars Publishing, UK
2. Gass S. I., Linear Programming, 5<sup>th</sup> Edition, McGraw Hill, NY
3. Hadley G., Linear Programming, Addison-Wesley Publishing Company, USA
4. Ray S. C., Data Envelopment Analysis: Theory and Techniques for Economics and Operations Research, Cambridge University Press, UK;
5. Vajda S., Mathematical Programming, Dover Publications, USA

| Year                 | Semester                 | Course No. | Course Title           | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 1 <sup>st</sup> Semester | STA357L    | Linear Programming Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge for solving linear programming problems.

#### Objectives

- Helping the students to develop ability to apply various linear programming methods in business/industrial data,
- Make the students to formulate the linear programming problems to optimize the profit/cost function when resources are found limited.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Formulate the linear programming problems and solve this by using appropriate methods such as, graphical method, algebraic method, simplex method, revised simplex method, two-phase method, Big-M method;  
 CLO2 Formulate the dual of a linear programming problem and solve it using real life example and hence point out primal solution;  
 CLO3 Estimate game value and make decision about opponent illustrated with example;  
 CLO4 Apply various methods of transportation problem and find out the value/method to optimize the cost function.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO2        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO3        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO4        |          |          | √        |          | √        |          | √        | √        |          | √         |

#### Contents of the Course

Formulation and solution of linear programming and integer linear programming problems, transportation problems, solution of two-person zero sum games.

#### Main Texts

1. Bazaraa M. S., Jarvis J. J., Sherali H. D., (2009), Linear programming and Network flows, 4<sup>th</sup> Edition, Wiley
2. Taha H. A., (2010), Introduction to Operation Research, 9<sup>th</sup> Edition, Pearson

#### Reference Books

1. Charnes V. & Kumar M., Data Envelopment Analysis and Its Applications to Management, Cambridge Scholars Publishing, UK
2. Gass S. I., Linear Programming, 5<sup>th</sup> Edition, McGraw Hill, NY
3. Hadley G., Linear Programming, Addison-Wesley Publishing Company, USA
4. Ray S. C., Data Envelopment Analysis: Theory and Techniques for Economics and Operations Research, Cambridge University Press, UK;
5. Vajda S., Mathematical Programming, Dover Publications, USA

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 1 <sup>st</sup> Semester | STA300A    | Presentation & Viva-voce | 0 + 0                     | 1.0     |

**Rationale of the Course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

#### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Develop verbal communication and presentation skills;
- CLO2 - Communicate their learning effectively and appropriately to formal audiences;
- CLO3 - Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;
- CLO4 - Prepare for professional oral examinations which is useful to enhance employment interview skills;
- CLO5 - Demonstrate their ability to participate in academic discussion.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO2        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO3        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO4        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO5        | √     | √     |       |       | √     |       |       | √     | √     | √      |

**Contents of the Course:**Comprehensive contents of all the underlying courses of the semester.

#### Main Text

- Textbooks referred for all the underlying courses of the semester.

#### Reference Books

- Reference books referred for all the underlying courses of the semester.

#### Third Year Second Semester Course Details

| Year                 | Semester                 | Course No. | Course Title                                         | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|------------------------------------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA352     | Stochastic Processes (Pre-requisites STA152, STA251) | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge to model the phenomena and systems that appear to vary not only in a random manner but also with time or any other index.

#### Objectives

- Acquaint students with the concepts of modern probability theory, generating functions, limit theorems and the collection of random variables,
- To facilitate necessary knowledge about Markov chain, derivation of equations and distributions for discrete-state stochastic processes,
- Help students to develop ability to evaluate the characteristics of stochastic systems.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Select the suitable probability function for a probability space;
- CLO2 - Define the convergence of a sequence of random variables;
- CLO3 - Formulate non-deterministic systems with Markov chains or Poisson processes and identify long-run behavior of chains or processes, especially in environment and business sectors;
- CLO4 - Apply the tools and techniques of queuing systems in public health, transportation and IT sectors to optimize the use of resources.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     | √     |       | √     |       |       |       |        |
| CLO2        | √     |       | √     | √     |       | √     |       |       |       |        |
| CLO3        | √     |       | √     | √     |       | √     |       |       |       |        |
| CLO4        | √     |       | √     | √     |       | √     |       |       |       |        |

#### Contents of the Course

**Modern Probability Theory:** Borel field and extension of probability measure, probability of a set function, probability measure notion of random variables, probability space, distribution functions.

**Generating Functions:** Characteristic functions and probability generating functions with properties.

**Convergence of Random Variables:** Convergence of random variables, convergence of distribution functions, laws of large numbers, central limit theorems, conditions, Martingales.

**Elementary Concepts of Stochastic Process:** Definition, different types of stochastic processes, Markov chain:homogeneous Markov process,transient states, transition matrix, higher transition probabilities, classification of states and chains, ergodic properties,

**Finite Markov Chain:** Evaluation of  $P^n$ , stability of a Markov system, general theory of random walk with reflecting barriers, absorption probabilities, application of recurrence time, gambler's ruin problem.

**Markov Process with Discrete State Space:** Poisson process and its related distributions

**Extension of Poisson Processes:** Generalizations of Poisson process, simple birth process, simple death process, simple birth-death process, general birth process, effect of immigration, non-homogeneous birth-death process, recurrent events, renewal equation, delayed recurrent events, number of occurrences of a recurrent event.

**Queueing Theory:** Kendall notation, M/M/1, M/M/1/N, M/M/m queues.

### Main Texts

1. Bhat, B. R., (2007), Modern probability theory: New Age International.
2. Roy, M. K., (2000), Fundamentals of Probability and Probability Distributions: Romax Publications.
3. Medhi, J., (1994), Stochastic processes: New Age International.
4. Ross, S. M., (2014), Introduction to probability models: Academic press
5. Sufian A. J. M., (2017), Stochastic Processes and Their Applications in Business, The University Press Limited

### Reference Books

1. Ash R. B., Real Analysis and Probability, Academic Press, USA
2. Bailey N. T. J., The Element of Stochastic Processes, Wiley Inter Science Publications, NY
3. Bartlett M. S., An Introduction to Stochastic Processes, 3<sup>rd</sup> Edition, Cambridge University Press, UK
4. Bhat U. N. & Miller G. K., Elements of Applied Stochastic Processes, 3<sup>rd</sup> Edition, Jhon Wiley & Sons, NY
5. Billingsley P., Probability and Measure, Anniversary Edition, Jhon Wiley & Sons, NY
6. Chung K. L. & Aitsahlia F., Elementary Probability Theory with Stochastic Processes, 4<sup>th</sup> Edition, Springer
7. Cox D. R. & Miller W., The Theory of Stochastic Processes, Chapman and Hall, London
8. Grimmett G. R. & Stirzaker D. R., Probability and Random Processes, 3<sup>rd</sup> Edition, Oxford University Press, UK
9. Karlin S. & Taylor H. M., A First Course in Stochastic Processes, 2<sup>nd</sup> Edition, Academic Press, NY
10. Ross S. M., Stochastic Processes, 2<sup>nd</sup> Edition, Jhon Wiley & Sons, NY
11. Taylor H. M. & Karlin S., An Introduction to Stochastic Modeling, 3<sup>rd</sup> Edition, Academic Press, NYD Irwin Inc, Homewood, Illinois

| Year                 | Semester                 | Course No. | Course Title                                             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|----------------------------------------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA352L    | Stochastic Processes Lab (Pre-requisites STA152, STA251) | 0 + 2                     | 1.0     |

**Rationale of the Course:** Securing the ability to solve and discuss dynamic advanced real-life problems based on the theory of stochastic processes.

### Objectives

- Make the students able to apply generating functions and limit theorems,
- To facilitate necessary skills to formulate Markov chain, derive equations,
- Helping the students to develop ability to evaluate the characteristics of stochastic systems.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Select the suitable probability function for a probability space;
- CLO2 Check the convergence of a sequence of random variables;
- CLO3 Formulate non-deterministic systems with Markov chains or Poisson processes and identify long-run behavior of chains or processes, especially in environment and business sectors;
- CLO4 Apply the tools and techniques of queueing systems in public health, transportation and IT sectors to optimize the use of resources.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       |       | √     | √     |       |       |       |       |       | √      |
| CLO2        |       |       | √     | √     |       |       |       |       |       | √      |
| CLO3        |       |       | √     | √     |       |       |       |       |       | √      |
| CLO4        |       |       | √     | √     |       |       |       |       |       | √      |

### Contents of the Course

**Elementary Concepts of Stochastic Process:** Markov chain:homogeneous Markov process,transient states, transition matrix, higher transition probabilities, classification of states and chains.

**Finite Markov Chain:** Evaluation of  $P^n$ , stability of a Markov system, general theory of random walk with reflecting barriers, absorption probabilities, application of recurrence time, gambler's ruin problem.

**Applications of Poisson Process:** Birth and death process, M/M/1, M/M/1/N, M/M/m queues

### Main Texts

1. Medhi, J., (1994), Stochastic processes: New Age International.
2. Ross, S. M., (2014), Introduction to probability models: Academic press.

### Reference Book

- Ross S. M., Stochastic Processes, 2<sup>nd</sup> Edition, Jhon Wiley & Sons, NY

| Year                 | Semester                 | Course No. | Course Title | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA354     | Demography   | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on theory of essential demographic elements.

### Objectives

- Acquaint students with vital events from various sources of demographic data,
- Provide knowledge on the techniques for detecting and adjusting for errors in data,
- To facilitate necessary knowledge about the components of population change.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Explain various components of demographic process;

CLO2 - Describe various methods of hidden errors in the datasets and devise ways of overcoming them;

CLO3 - Explain elementary knowledge on fertility, mortality, marriage, migration;

CLO4 - Compare fertility and mortality measures of different regional population;

CLO5 - Develop idea to categorize migration and its various measures;

CLO6 - Analyze the demographic characteristics of a given population;

CLO7 - Forecast population by using various projection methods.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          |          |          | √        |          | √        |          |          | √         |
| CLO2        | √        |          |          |          | √        |          | √        |          |          | √         |
| CLO3        | √        |          |          |          | √        |          | √        |          |          | √         |
| CLO4        | √        |          |          |          | √        |          | √        |          |          | √         |
| CLO5        | √        |          |          |          | √        |          | √        |          |          | √         |
| CLO6        | √        |          |          |          | √        |          | √        |          |          | √         |
| CLO7        | √        |          |          |          | √        |          | √        |          |          | √         |

### Contents of the Course

Basic concept of demography: demography and population studies, nature and scope of demography, importance of demography, vital statistics, demographic characteristics in Bangladesh.

Sources of demographic data: census, survey, population register, sample vital registration system in Bangladesh. Sources and types of errors in demographic data, detection and reduction of errors, the stock and flow data.

Introduction to demographic methods: rates, ratios, proportions, cohort, age-sex composition, rates of vital events, errors in age data, detection of errors in age data, population pyramid, concept of population change, rates of population growth and its different measures, balancing equation, history of population growth in Bangladesh.

Fertility and its measures: crude birth rate, general fertility rate, age-specific fertility rate, total fertility rate, sex ratio, child woman ratio, cohort fertility rate, marital fertility rate, number of children ever born, cumulative fertility, fertility differentials, gross and net reproduction rate.

Mortality and its measures: crude death rate, age-specific death rate, live birth, still birth, neo-natal, infant death rate, infant and child mortality, adjusted infant mortality.

Nuptiality and its measures: concept of marriage, divorce, separation, estimation of mean and median age at marriage, estimation of singulate mean age at marriage, nuptiality table.

Standardization of rates and ratios: concept, need and methods of standardization.

Life table: definition, importance and classification, function, construction and application, force of mortality. Migration: definition, types of migration, effect of migration, various measures of migration.

Population projections: definition, importance, various methods of projection, application and use of different methods of projections with special reference to Bangladesh.

Growth curve: fitting of exponential, Gompertz and logistic curve.

### Main Texts

1. Kpedekpo G. M. K., (1982), Essentials of Demographic Analysis for Africa, Heinemann, London
2. Islam M. N, (2015), An Introduction to Demographic Techniques, Mullick & Brothers, Dhaka
3. Preston S. H., Heuveline P., Guilot M., (2001), Demography: Measuring and Modeling Population Process, Blackwell Publishers, USA
4. Rowland D. T., (2003), Demographic Methods and Concepts, Oxford University Press Inc., New York, USA

### Reference Books

1. Barclay J, Techniques of Population Analysis, John Wiley & Sons, NY
2. Bartlett M S, Stochastic Population Models in Ecology and Epidemiology, Methuen, Wiley
3. Bather R W, Mortality Table Construction, Prentice Hall
4. Bogue D, Principles of Demography, John Wiley & Sons, NY
5. Cox D R, Demography, 5<sup>th</sup> Edition, Cambridge University Press, Cambridge
6. Goon A M & Gupta M N, Fundamentals of Applied Statistics Vol-II
7. Keyfitz N, Introduction to Mathematics of Population, Addison-Wesley, USA
8. Pollard A H, *et al*, Demography, Willey Eastern, India
9. Spiegelman M, Introduction to Demography, Revised edition, Harvard University Press, Cambridge
10. Shryock H & Siegel J, The Method and Materials of Demography, Academic Press, NY

| Year                 | Semester                 | Course No. | Course Title   | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|----------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA354L    | Demography Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Acquiring knowledge to apply various demographic tools and techniques for analyzing real life data.

### Objectives

- Make the students able to apply different demographic tools and techniques into real life data,
- Helping the students to generate adequate information to describe the scenario of a country,
- To facilitate necessary skills to contribute by estimation of demographic components for proper planning of the nation.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Apply various demographic measures into real life data;

CLO2 - Construct population pyramid and life table;

CLO3 - Estimate growth rate by using different mathematical models;

CLO4 - Forecast specific population;

CLO5 - Provide appropriate estimates for proper planning.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO2        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO3        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO4        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO5        |          |          | √        |          | √        |          | √        | √        |          | √         |

### Contents of the Course

Calculation of various rates, ratios, proportions for demographic data (CBR, CDR, GRR, NRR, TFR, SR, etc.) construction of population pyramid, calculation of various measures of population growth, construction of life tables (*complete* and *abridge*), calculation of various measures of population growth, construction of life tables (*complete* and *abridge*), calculation of standardized death rate and ratios, fitting of growth curves. Other topics as covered in the theory part.

### Main Texts

1. Kpedekpo G. M. K., (1982), Essentials of Demographic Analysis for Africa, Heinemann, London
2. Islam M. N, (2015), An Introduction to Demographic Techniques, Mullick & Brothers, Dhaka
3. Preston S. H., Heuveline P., Guilot M., (2001), Demography: Measuring and Modeling Population Process, Blackwell Publishers, USA
4. Rowland D. T., (2003), Demographic Methods and Concepts, Oxford University Press Inc., New York, USA

### Reference Books

1. Bogue D., Principles of Demography, John Wiley & Sons, NY
2. Cox D. R., Demography, 5<sup>th</sup> Edition, Cambridge University Press, Cambridge
3. Keyfitz N., Introduction to Mathematics of Population, Addison-Wesley, USA
4. Pollard A. H., *et al*, Demography, Willey Eastern, India

5. Spiegelman M., Introduction to Demography, Revised edition, Harvard University Press, Cambridge
6. Shryock H. & Siegel J., The Method and Materials of Demography, Academic Press, NY

| Year                 | Semester                 | Course No. | Course Title               | Hours/Week (Theory) | Credits |
|----------------------|--------------------------|------------|----------------------------|---------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA356     | Statistical Computing – II | 2 + 0               | 2.0     |

**Rationale of the Course:** Acquiring knowledge to perform basic statistical computing algorithms and data analysis.

### Objectives

- Enhancing the skills of basic operations in SAS and R,
- Help students to develop ability in solving basic statistical problems using R and SAS,
- Foster the analytical and critical thinking ability to write code in SAS and R,
- Provide knowledge of properly assessing perfections of a program written in SAS and R.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Carry out the basic simulation mechanism and apply it to R;

CLO2 - Demonstrate data management within SAS and R;

CLO3 - Explore small and big datasets by using graphical representation and summary statistics;

CLO4 - Conduct inferential statistical analyses using SAS and R and interpret the output;

CLO5 - Diagnose model fitting criteria using SAS and R;

CLO6 - Write down basic programs to solve different statistical problems.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO2        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO3        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO4        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO5        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO6        | √        |          | √        | √        |          | √        | √        |          |          | √         |

### Contents of the Course

**Simulation:** Introduction to simulation-concept and meaning of simulation studies and modelling; Basic nature of simulation, discrete and continuous simulation; random number generation, random variate generation details; Series and their convergence; simple Monte Carlo integration, Polynomial and relational functions, incomplete gamma function, incomplete beta function, error function, chi-square probability function, cumulative probability function, exponential integrals,

Student's t distribution, F distribution, cumulative binomial distribution, hypergeometric distribution, multidimensional function minimization.

**Statistical Analysis System (SAS):** Introduction to using the SAS software program, Structure of a SAS program, data step, data management and other facilities in the DATA step, saving and recalling SAS programs, input statement, SAS permanent data sets, PROC steps – PRINT, SORT, FORMAT, MEANS, UNIVARIATE, TABULATE, CORR, SUMMARY, CONTENTS, TRANSPOSE, FREQ, T-TEST, ANOVA, GLM, REG, PLOT, SAS graphics.

**R-Language:** Overview of R, basic operations, list and data frames, data management, grouping, loops and conditional execution, functions; Summary statistics and graphical procedures; Statistical models in R, fitting distributions with R; R for simulation and modelling, simulation case studies.

### Main Texts

1. Ross S. M., (2006), Simulation, 4<sup>th</sup> Edition, Academic Press, London
2. Der G. & Brian S. E., (2008), A Handbook of Statistical Analyses Using SAS, 3<sup>rd</sup> Edition, CRC Press
3. Cohen Y. & Cohen J. Y., (2008), Statistics and Data with R: An applied approach through examples, John Wiley & Sons
4. Rahman M. S., (2017), R Programming and Data Analysis, 1<sup>st</sup> Edition, Kazi Prokashoni, Dhaka

### Reference Books

1. Cody R., SAS® by Example: A Programmer's Guide, SAS Institute
2. Cody R., SAS® Functions by Example, 2<sup>nd</sup> Edition, SAS Institute
3. Cody R., SAS® Statistics by Example, SAS Institute
4. Crawley M. J., The R Book, 2<sup>nd</sup> Edition, Wiley, NY
5. Raithel M. A., How to Become a Top SAS® Programmer, SAS Institute
6. Graham C. & Talay D., (2013), Stochastic simulation and Monte Carlo methods: mathematical foundations of stochastic simulation (Vol. 68). Springer Science & Business Media.
7. Ripley D Brian, Stochastic Simulation, Wiley, NY
8. Rubinstein Y R, Simulation and the Monte Carlo Method, Wiley, NY
9. SAS, Reference Manual: Language Guide for Personal Computers, Procedures Guide, STAT User's Guide
10. Verzani J, Using R for Introductory Statistics, Chapman & Hall/CRC, NY

| Year                 | Semester                 | Course No. | Course Title                   | Hours/Week (Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------------|------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA356L    | Statistical Computing – II Lab | 0 + 4            | 2.0     |

**Rationale of the Course:** Acquiring skill to perform basic statistical computing algorithms and data analysis.

### Objectives

- Make the students to conduct basic operations in SAS and R,
- Helping the students to solve basic statistical problems using R and SAS.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Simulate data with R;

CLO2 - Achieve data management skills in SAS and R;

CLO3 - Explore small and big datasets by using graphical representation and summary statistics;

CLO4 - Solve inferential statistical problems using SAS and R and interpret the output;

CLO5 - Diagnose model fitting criteria using SAS and R;

CLO6 - Carry out statistical programming techniques.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       |       | √     | √     |       | √     | √     |       |       | √      |
| CLO2        |       |       | √     | √     |       | √     | √     |       |       | √      |
| CLO3        |       |       | √     | √     |       | √     | √     |       |       | √      |
| CLO4        |       |       | √     | √     |       | √     | √     |       |       | √      |
| CLO5        |       |       | √     | √     |       | √     | √     |       |       | √      |
| CLO6        |       |       | √     | √     |       | √     | √     |       |       | √      |

### Contents of the Course

**Statistical Analysis System (SAS):** Getting into SAS, data management in SAS: the data steps, using existing data files, splitting data sets, if conditions, joining data sets, merging data sets, updating and selecting variables, saving program, labelling and formatting, permanent data set, Summary statistics including graphical representation of data-pie chart, histogram and so on, Making new SAS data sets, Analysis of randomized block design, treatment comparisons, analysis of non-orthogonal designs, split-plot analysis, Regression including ANOVA in SAS – all possible regressions, sequential methods, model diagnostics, comparisons of regressions.

**R-Language:** A basic operation in R programming, Data management in R, Graphical representation of data-XY plot, bar chart, pie chart, histogram and so on. Data analysis using R: Regression including ANOVA, all possible regressions, sequential methods, model diagnostics, comparisons of regressions, Analysis of randomized block design, treatment comparisons, analysis of non-orthogonal designs, split-plot analysis, Other topics as covered in the theory part.

### Main Texts

1. Ross S. M., (2006), Simulation, 4<sup>th</sup> Edition, Academic Press, London
2. Der G. & Brian S. E., (2008), A Handbook of Statistical Analyses Using SAS, 3<sup>rd</sup> Edition, CRC Press
3. Cohen Y. & Cohen J. Y., (2008), Statistics and Data with R: An applied approach through examples, John Wiley & Sons

- Rahman M. S., (2017), R Programming and Data Analysis, 1st Edition, Kazi Prokashoni, Dhaka

#### Reference Books

- Cody R., SAS® by Example: A Programmer's Guide, SAS Institute
- Cody R., SAS® Functions by Example, 2<sup>nd</sup> Edition, SAS Institute
- Cody R., SAS® Statistics by Example, SAS Institute
- Crawley M. J., The R Book, 2<sup>nd</sup> Edition, Wiley, NY
- Raithel M A, How to Become a Top SAS® Programmer, SAS Institute
- SAS, Reference Manual: Language Guide for Personal Computers, Procedures Guide, STAT User's Guide
- Verzani J, Using R for Introductory Statistics, Chapman & Hall/CRC, NY

| Year                 | Semester                 | Course No. | Course Title                                             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|----------------------------------------------------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA358     | Regression Analysis – II (Pre-requisite STA252, STA252L) | 3 + 0                     | 3.0     |

**Rationale of the Course:** Providing students with a comprehensive understanding of the advanced statistical tools employed for linear regression.

#### Objectives

- Provide a thorough foundation for general linear regression model,
- To facilitate necessary knowledge on fitting regression models,
- To provide knowledge of understanding sampling distribution of parameter estimates,
- Foster analytical and critical thinking ability to carry out hypothesis tests and model diagnostics,
- To enhance skills of alternative model fitting in case of violation of classical assumptions.

**Course Learning Outcomes:** At the end of course, students will be able to -

CLO1 - Fit simple linear regression model and check the model assumptions;  
 CLO2 - Fit multiple linear regression model and check the model assumptions;  
 CLO3 - Transform predictors and response variables to improve model fit;  
 CLO4 - Assess parameter estimates globally, in subsets, and individually;  
 CLO5 - Deal with categorical predictors and handle interactions among predictors;  
 CLO6 - Address econometric problems such as autocorrelation, multicollinearity, etc;

CLO7 - Identify errors in variables and solve issues related to such errors;

CLO8 - Create and study dummy variables and use it in data analysis;

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     | √     |       | √     | √     |       |       | √      |

|      |   |  |   |   |  |   |   |  |  |   |
|------|---|--|---|---|--|---|---|--|--|---|
| CLO2 | √ |  | √ | √ |  | √ | √ |  |  | √ |
| CLO3 | √ |  | √ | √ |  | √ | √ |  |  | √ |
| CLO4 | √ |  | √ | √ |  | √ | √ |  |  | √ |
| CLO5 | √ |  | √ | √ |  | √ | √ |  |  | √ |
| CLO6 | √ |  | √ | √ |  | √ | √ |  |  | √ |
| CLO7 | √ |  | √ | √ |  | √ | √ |  |  | √ |
| CLO8 | √ |  | √ | √ |  | √ | √ |  |  | √ |

#### Contents of the Course

Multiple regression and linear estimation: generalized and weighted least squares. Gauss-Markov Aitken's theorem. Estimation and tests for linear restriction.

Heteroscedasticity: detection and testing for heteroscedasticity, estimation with heteroscedastic disturbances. Multicollinearity: concept of exact and near multicollinearity, estimable functions, effects of multicollinearity, detection and remedial measures of multicollinearity. Selection of variables.

Autocorrelation: sources and consequences of autocorrelation, tests for autocorrelated disturbances, estimation of parameters.

Dummy variables: general concepts, use of dummy variables in regression analysis.

Errors in variables: basic ideas, consequences and tests for error in variables, estimation of parameters, errors in equation.

#### Main Texts

- Gujarati D. N., (2009), Basic Econometrics, 3<sup>rd</sup> Edition, McGraw Hill, NY
- Johnston J., (1979), Econometric Methods, McGraw Hill, NY
- Neter, J., *et al*, (1983), Applied Linear Regression Models, Richard D Irwin Inc, Homewood, Illinois

#### Reference Books

- Chatterjee S., & Price B., (2012), Regression Analysis by Example, 5<sup>th</sup> Edition, John Wiley & Sons, NY
- Draper N. R. & Smith H., (1998), Applied Regression Analysis, 3<sup>rd</sup> Edition, John Wiley & Sons, NY
- Griffiths W. E., *et al*, (1994), Learning and Practicing Econometrics, 1<sup>st</sup> Edition, John Wiley & Sons, NY
- Judge, G. G., *et al*, (1985), The Theory and Practice of Econometrics, 2<sup>nd</sup> Edition, John Wiley & Sons, NY
- Koutsoyiannis, A., (2001), Theory of Econometrics, 2<sup>nd</sup> Edition, Macmillan, London
- Montgomery, D. C., & Peck, E. A., (2012), Introduction to Linear Regression Analysis, John Wiley & Sons, NY

| Year                 | Semester                 | Course No. | Course Title                                                 | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------------------------------------------|---------------------------|---------|
| 3 <sup>rd</sup> year | 2 <sup>nd</sup> semester | STA358L    | Regression Analysis – II Lab (Pre-requisite STA252, STA252L) | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired empirical knowledge of fitting multiple linear regression models through data.

### Objectives

- Familiarize students with the skills of fitting multiple linear regression models,
- Helping the students to test multicollinearity, autocorrelation in data and fitting models after removing those problems,
- Make the students to fit models with dummy variables and perform tests of hypotheses.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Fit simple linear regression model and check the model assumptions;

CLO2 - Fit multiple linear regression model and check the model assumptions;

CLO3 - Detect violation of assumptions and fit models after removing these problems;

CLO4 - Transform predictors and response variables to improve model fit;

CLO5 - Fit models with dummy variables and perform tests of hypotheses.

CLO6 - Overcome econometric problems such as autocorrelation, multicollinearity, etc;

CLO7 - Create and study dummy variables and use it in data analysis;

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          |          |          | √        |          | √        |          | √        |          | √         |
| CLO2        |          |          |          | √        |          | √        |          | √        |          | √         |
| CLO3        |          |          |          | √        |          | √        |          | √        |          | √         |
| CLO4        |          |          |          | √        |          | √        |          | √        |          | √         |
| CLO5        |          |          |          | √        |          | √        |          | √        |          | √         |
| CLO6        |          |          |          | √        |          | √        |          | √        |          | √         |
| CLO7        |          |          |          | √        |          | √        |          | √        |          | √         |

### Contents of the Course

Fitting of multiple regression models, tests of parameters of a multiple regression model. Detection and tests for heteroscedasticity, multicollinearity, fitting of model after removing these problems. Tests of autocorrelation and estimation of parameters with autocorrelated disturbances. Fitting of dummy variables model and tests.

### Main Texts

1. Gujarati D. N., (2009), Basic Econometrics, 3<sup>rd</sup> Edition, McGraw Hill, NY
2. Johnston J., (1979), Econometric Methods, McGraw Hill, NY
3. Neter, J., *et al*, (1983), Applied Linear Regression Models, Richard D Irwin Inc, Homewood, Illinois

### Reference Books

1. Chatterjee S., & Price B., (2012), Regression Analysis by Example, 5<sup>th</sup> Edition, John Wiley & Sons, NY
2. Draper N. R. & Smith H., (1998), Applied Regression Analysis, 3<sup>rd</sup> Edition, John Wiley & Sons, NY

3. Griffiths W. E., *et al*, (1994), Learning and Practicing Econometrics, 1<sup>st</sup> Edition, John Wiley & Sons, NY
4. Judge, G. G., *et al*, (1985), The Theory and Practice of Econometrics, 2<sup>nd</sup> Edition, John Wiley & Sons, NY
5. Koutsoyiannis, A., (2001), Theory of Econometrics, 2<sup>nd</sup> Edition, Macmillan, London
6. Montgomery, D. C., & Peck, E. A., (2012), Introduction to Linear Regression Analysis, John Wiley & Sons, NY

| Year                 | Semester                 | Course No. | Course Title | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------|---------------------------|---------|
| 3 <sup>rd</sup> Year | 2 <sup>nd</sup> Semester | STA360     | Field Work   | 7 Days                    | 1.0     |

**Rationale of the Course:** Acquiring practical experience of collecting data with a tour to an industry or organization or institution or by a field visit.

### Objectives

- Acquaint students to develop necessary skills to communicate with stake holders,
- Provide students with hands-on experience of collecting data from various sources,
- Facilitate students to develop industry-academia collaboration and networking.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Conduct field survey to collect necessary data from relevant sources;
- CLO2 Apply appropriate sampling technique to obtain a representative sample;
- CLO3 Develop effective collaboration with various industries, organizations and institutions to collect necessary data and undertake collaborative research, which will be beneficial for their future job placement;
- CLO4 Illustrate hands-on experience of physically visiting the field of study and having direct interaction with the study subjects or experimental units;
- CLO5 Demonstrate report writing and presentation skills of disseminating outcome of the field works.

### Mapping CLOs to PLOs

| CLO / PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1      |          | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO2      |          | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO3      |          | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO4      |          | √        |          |          | √        |          | √        | √        | √        | √         |
| CLO5      |          | √        |          |          | √        |          | √        | √        | √        | √         |

### Contents of the Course

The topic and location of the field work will be decided by a general meeting of the teachers of the department. A small group of students will be assigned to teachers by the department for supervision. The evaluation will be made jointly by supervisors and chairman of the respective examination committee. All students will have to submit a written report through their assigned teachers to the department.

| Year                    | Semester                    | Course No. | Course Title                | Hours/Week<br>(Theory + Lab) | Credits |
|-------------------------|-----------------------------|------------|-----------------------------|------------------------------|---------|
| 3 <sup>rd</sup><br>Year | 2 <sup>nd</sup><br>Semester | STA300B    | Presentation &<br>Viva-voce | 0 + 0                        | 1.0     |

**Rationale of the Course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

#### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Develop verbal communication and presentation skills;  
CLO2 Communicate their learning effectively and appropriately to formal audiences;  
CLO3 Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;  
CLO4 Prepare for professional oral examinations which is useful to enhance employment interview skills;  
CLO5 Demonstrate their ability to participate in academic discussion.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO2        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO3        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO4        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO5        | √        | √        |          |          | √        |          |          | √        | √        | √         |

**Contents of the Course:** Comprehensive contents of all the underlying courses of the semester.

#### Main Text

- Textbooks referred for all the underlying courses of the semester.

#### Reference Books

- Reference books referred for all the underlying courses of the semester.

#### Fourth Year First Semester Course Details

| Year                    | Semester                    | Course No. | Course Title           | Hours/Week<br>(Theory + Lab) | Credits |
|-------------------------|-----------------------------|------------|------------------------|------------------------------|---------|
| 4 <sup>th</sup><br>Year | 1 <sup>st</sup><br>Semester | STA451     | Economic<br>Statistics | 3 + 0                        | 3.0     |

**Rationale of the Course:** Acquiring knowledge on the statistical methods of analyzing economic data.

#### Objectives

- Make the students understand the concept of consumer and producer behavior,
- Acquaint students with different types of economic indices,
- Familiarize students with the concepts of different growth models.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Describe methods of analyzing consumer behavior;  
CLO2 Explain about issues in income and wealth inequalities, characteristics and measures;  
CLO3 Compute different economic indices and apply those in comparison purposes;  
CLO4 Carry out optimum production analysis;  
CLO5 Evaluate inter industrial relationships;  
CLO6 Employ different growth models in development planning.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO2        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO3        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO4        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO5        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO6        | √        |          | √        |          | √        |          | √        | √        |          | √         |

#### Contents of the Course

**Attributes of consumer behavior:** Engel curves and lognormal demand curves. Maximization of utility, demand function, price, income and cross elasticities of demand. Preference theory of demand.

**Distribution of personal income:** Empirical distribution, Pareto's law, Lorenz curve, Concentration ratio, The lognormal distribution, Stochastic model of income distribution.

**Theory of production:** Production function, concepts of average productivity, marginal productivity, marginal rate of technical substitution, efficiency of production, factor intensity, returns to scale and homogeneity of production function, production possibility curve, cost function, minimizing cost for a given level of output, maximization of profit subject to constraint cost, maximization of profit for a given output, Cobb-Douglas production function, constant elasticity substitution (CES) production function.

**Dynamic economics:** Cobweb model, Harrod-Domar model of economic growth, Natural and non-natural technical change, two sector growth models.

**Input output analysis:** Meaning of input output, main features of input output, assumptions, Leontiefs static and dynamic model, limitations, importance and application of the analysis.

### Main Texts

1. Allen R. G. D., (1970), Mathematical Economics, MacMillan, London
2. Chiang K., Alpha C., Wainwright, (2005), Fundamental Methods of Mathematical Economics, 4<sup>th</sup> Edition, McGraw Hill, NY
3. Singh S. P., Parashar A. K., Singh H. P., (1999), Econometrics and mathematical economics, S. Chand and Company, 7<sup>th</sup> Revised Edition

### Reference Books

1. Bridge J. L., Applied Econometrics, North Holland, Amsterdam
2. Chatfield C., The Analysis of Time Series: An Introduction, 6<sup>th</sup> Edition, Chapman & Hall, London
3. Gupta S. C. & Kapoor V. K., Fundamentals of Applied Statistics, 4<sup>th</sup> Reprint Edition, Sultan Chand & Sons, New Delhi
4. Henderson J. M. & Quandt R. E., Microeconomic Theory: A Mathematical Approach, 3<sup>rd</sup> Edition, McGraw Hill, NY
5. Kakwani N. C., (1980), Income Inequality and Poverty: Methods of Estimation and Policy Application, A World Bank Research Publication by Oxford University Press
6. Klein L. R., An Introduction to Econometrics, Literary Licensing, LLC
7. Koutsoyiannis A., Modern Microeconomics, 2<sup>nd</sup> Edition, Macmillan, London

| Year                 | Semester                 | Course No. | Course Title            | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 1 <sup>st</sup> Semester | STA451L    | Economic Statistics Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge on the statistical methods of analyzing economic data.

### Objectives

- Helping the students to estimate time series components,
- Provide the knowledge to fit income and wealth distributions,
- Helping the students to estimate various production functions.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Fit and analyze different income distributions;

CLO2 - Estimate and interpret the parameters of the production functions;

CLO3 - Conduct different input-output analysis.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       |       | √     |       | √     |       | √     | √     |       | √      |
| CLO2        |       |       | √     |       | √     |       | √     | √     |       | √      |
| CLO3        |       |       | √     |       | √     |       | √     | √     |       | √      |

### Contents of the Course

Fitting of Pareto and lognormal distribution, Lorenz curve and Gini's concentration ratio, estimation of production functions: Cobb-Douglas (CD), CES, trans-log, generalized forms of CD and CES production functions. Computation of Engel's elasticities. Input output analysis.

### Main Texts

1. Allen R. G. D., (1970), Mathematical Economics, MacMillan, London
2. Chiang K., Alpha C., Wainwright, (2005), Fundamental Methods of Mathematical Economics, 4<sup>th</sup> Edition, McGraw Hill, NY
3. Singh S. P., Parashar A. K., Singh H. P., (1999), Econometrics and mathematical economics, S. Chand and Company, 7<sup>th</sup> Revised Edition

### Reference Books

1. Bridge J. L., Applied Econometrics, North Holland, Amsterdam
2. Chatfield C., The Analysis of Time Series: An Introduction, 6<sup>th</sup> Edition, Chapman & Hall, London
3. Gupta S. C. & Kapoor V. K., Fundamentals of Applied Statistics, 4<sup>th</sup> Reprint Edition, Sultan Chand & Sons, New Delhi
4. Kakwani N. C., (1980), Income Inequality and Poverty: Methods of Estimation and Policy Application, A World Bank Research Publication by Oxford University Press
5. Klein L. R., An Introduction to Econometrics, Literary Licensing, LLC
6. Koutsoyiannis A., Modern Microeconomics, 2<sup>nd</sup> Edition, Macmillan, London

| Year                 | Semester                 | Course No. | Course Title       | Hours/Week (Theory + Lab.) | Credits |
|----------------------|--------------------------|------------|--------------------|----------------------------|---------|
| 4 <sup>th</sup> Year | 1 <sup>st</sup> Semester | STA453     | Applied Statistics | 3 + 0                      | 3.0     |

**Rationale of the Course:** Acquiring knowledge to the key areas of official statistics, industrial statistics and educational statistics.

### Objectives

- Acquaint students with statistical tools for quality control in industry,
- Provide knowledge of time series data and prediction,
- Acquaint students with various types of index numbers,
- To facilitate necessary knowledge on various statistical tools to analyze educational and psychological data,
- To develop skills to collect, analyze and represent quantitative and qualitative information in the official statistics.

**Course Learning Outcomes:** At the end of the course, students will be able to –

CLO1 - Apply different statistical quality control techniques in industry;

CLO2 - Plan acceptance sampling;

CLO3 - Perform sequential sampling procedure;

CLO4 – Interpret different components of time series;

CLO5 – Compute various types of economic index numbers and apply those in comparison purposes;

CLO6 - Identify and use statistical tools to analyze educational and psychological data;

CLO7 - Illustrate the key aspects of official statistics in Bangladesh;

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        | √        | √        |          | √        |          |          | √         |
| CLO2        | √        |          | √        | √        | √        |          | √        |          |          | √         |
| CLO3        | √        |          | √        | √        | √        |          | √        |          |          | √         |
| CLO4        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO5        | √        |          | √        |          | √        |          | √        | √        |          | √         |
| CLO6        | √        |          | √        | √        | √        |          | √        |          |          | √         |
| CLO7        | √        |          | √        | √        | √        |          | √        |          |          | √         |

#### Contents of the Course

**Industrial statistics:** Assignable and non-assignable causes of variations, problems and principle of statistical quality control, control charts for variables, control charts for attributes, special control charts.

Acceptance sampling procedure: introduction, acceptance sampling by attributes, consumer's and producer's risk, acceptance sampling by variables, continuous sampling plan. Sequential sampling, OC, ASN, SPRT.

**Time series:** General ideas, Decomposition, Trend, Seasonality. Different methods of finding trend & seasonality.

**Index number:** Problems in construction of index numbers, purpose of the index, price index, quantity index, value index, tests of index numbers, cost of living index, family budget method.

**Educational statistics:** introduction, education and psychology, scaling, measurement of different scores, IQ, planning reliability, validity of tests.

**Official statistics:** Official statistics of Bangladesh with special reference to population, economy; critical evaluation of the sources and their limitations.

#### Main Texts

1. Leavenworth, R. S., & Grant, E. L. (2004), Statistical Quality Control, 7<sup>th</sup> Edition, Tata McGraw Hill, India
2. Guilford J. P. & Benjamin F., (1977), Fundamental Statistics in Psychology and Education, 6<sup>th</sup> Edition, McGraw Hill

#### Reference Books

1. Banks J., Principles of Quality Control, 1<sup>st</sup> Edition, Wiley
2. Duncan A. J., Quality Control and Industrial Statistics, 5<sup>th</sup> Edition, Irwin Publication
3. Guilford J. P., Psychometric Methods, McGraw Hill, NY
4. Gupta S. C., Kapoor V. K., Applied Statistics, Sultan Chand & Sons, New Delhi, India
5. Publications of BBS, Bangladesh Bank, NIPORT and Other Organizations

6. Wordsworth H. M., *et al*, Modern Methods for Quality Control and Improvement, 2<sup>nd</sup> Edition, Wiley

| Year                 | Semester                 | Course No. | Course Title           | Hours/Week (Theory + Lab.) | Credits |
|----------------------|--------------------------|------------|------------------------|----------------------------|---------|
| 4 <sup>th</sup> Year | 1 <sup>st</sup> Semester | STA453L    | Applied Statistics Lab | 0 + 4                      | 2.0     |

**Rationale of the Course:** Application of acquired knowledge to the key areas of industrial statistics and educational statistics.

#### Objectives

- Make the students able to use statistical tools for quality control in industry,
- Make students to determine price, quantity, value, and cost of living indices using different methods;
- Helping the students to estimate time series components;
- Help the students to analyze educational and psychological data using statistical tools.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Apply different statistical quality control techniques in industry;

CLO2 - Apply different acceptance sampling procedures;

CLO3 – Compute price, quantity, value, and cost of living indices and their interpretations;

CLO4 - \Detect and remove different components in time series data;

CLO5 - Use statistical tools to analyze educational and psychological data.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO2        |          |          | √        | √        | √        |          | √        | √        |          | √         |
| CLO3        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO4        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO5        |          |          | √        | √        | √        |          | √        | √        |          | √         |

**Contents of the Course:** Different types of control charts, OC curve for single sampling and double sampling plans, calculation of AOQ and AOQL for single sampling, double sampling and continuous sampling plans. OC curve and ASN functions for multiple sampling plans. Calculation of different scores and their standardization, calculation of IQ. Construction of price, quantity, value index and cost of living index, determination of trend and seasonal variation.

#### Main Texts

1. Leavenworth, R. S., & Grant, E. L. (2004), Statistical Quality Control, 7<sup>th</sup> Edition, Tata McGraw Hill, India
2. Guilford J. P. & Benjamin F., (1977), Fundamental Statistics in Psychology and Education, 6<sup>th</sup> Edition, McGraw Hill

## Reference Books

1. Banks J., Principles of Quality Control, 1<sup>st</sup> Edition, Wiley
2. Duncan A. J., Quality Control and Industrial Statistics, 5<sup>th</sup> Edition, Irwin Publication
3. Guilford J. P., Psychometric Methods, McGraw Hill, NY
4. Gupta S. C., Kapoor V. K., Applied Statistics, Sultan Chand & Sons, New Delhi, India
5. Publications of BBS, Bangladesh Bank, NIPORT and Other Organizations
6. Wordsworth H. M., *et al*, Modern Methods for Quality Control and Improvement, 2<sup>nd</sup> Edition, Wiley

| Year                 | Semester                 | Course No. | Course Title                                                          | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------------------------------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 1 <sup>st</sup> Semester | STA455     | Design & Analysis of Experiments – II (Pre-requisite STA351, STA351L) | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on advanced design of experiments.

## Objectives

- To facilitate necessary knowledge about estimable function and tests of hypothesis,
- Foster the analytical and critical thinking ability to prepare layout and analyze data from incomplete block design of experiments,
- To provide knowledge on layout and analysis of confounded factorial design of experiments,
- To provide knowledge of asymmetric factorial designs,
- To develop skills on analysis of covariance.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Explain estimable function and identify conditions for estimability;
- CLO2 Estimate parameters and carry out tests of hypotheses regarding parameters for analysis of variance models;
- CLO3 - Layout incomplete block experiments and analyze data;
- CLO4 Prepare confounded factorial experiment and advanced experimental designs and carry out analysis of data from such designs;
- CLO5 Outline design and analyze data from asymmetrical experiments;
- CLO6 Implement experimental designs appropriate for agricultural and engineering sectors.

## Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO2        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO3        | √     | √     | √     |       | √     |       | √     |       |       | √      |

|      |   |   |   |  |   |  |   |  |  |   |
|------|---|---|---|--|---|--|---|--|--|---|
| CLO4 | √ | √ | √ |  | √ |  | √ |  |  | √ |
| CLO5 | √ | √ | √ |  | √ |  | √ |  |  | √ |
| CLO6 | √ | √ | √ |  | √ |  | √ |  |  | √ |

## Contents of the Course

Linear estimation, estimable parametric functions and conditions for estimability, methods of estimation for analysis of variance models, solution of normal equations for less than full rank, optimality properties of least squares estimators, test of hypothesis.

Weighing design: method of estimation. Use of incomplete blocks, construction and analysis of BIB designs, incomplete block design as weighting designs (intra and inter-block analysis). Missing plot. Orthogonal Latin squares. Youden squares. Lattice designs. Partially balanced incomplete block designs.

Factorial experiment:  $s^n$  factorial experiments and their analysis. Confounding, total, partial and simultaneous confounding in two and three levels up to  $n$  factors, fractional replicates and their construction. Asymmetric factorial experiments.

Split-plot design: analysis of split-plot design, split-split-plot design: analysis of split-split-plot design, strip-plot design: analysis of strip-plot design, nested design: analysis of nested design.

Analysis of covariance: analysis of covariance of non-orthogonal data in two-way classification. Analysis of covariance with one and more than one ancillary variables. Covariance and analysis of experiments with missing observations, transformation.

## Main Texts

1. Montgomery D C, (2020), Design and Analysis of Experiments, 10<sup>th</sup> Edition, Wiley, NY
2. Das M. N. & Giri N. C., (2017), Design and Analysis of Experiments, 3<sup>rd</sup> Edition, New Age International, Delhi
3. Sahai H. & Ageel, M. I., (2000), The Analysis of Variance: Fixed. Random and Mixed Models, MA: Birkhauser, Boston

## Reference Books

1. Bhuyan M. R., Fundamentals of Experimental Design, 2<sup>nd</sup> Edition, Book World Publications, Dhaka
2. Cochran W. G. & Cox D. R., Experimental Design, 2<sup>nd</sup> Edition, John Wiley & Sons, NY
3. Federer W. T., Experimental Design: Theory and Application, Oxford & IBH Publishing Company, NY
4. Gomez K. A. & Gomez A. A., Statistical Procedures for Agricultural Research, 2<sup>nd</sup> Edition, Wiley, NY
5. Kempthorne O, The Design and Analysis of Experiment, Reprint Edition, Wiley, NY
6. Winer B. J., Statistical Principles in Experimental Design, 2<sup>nd</sup> Ed., McGraw Hill Company, Ltd
7. Yates F., Design and Analysis of Factorial Experiments, Harpenden Herts, England

| Year | Semester | Course | Course Title | Hours/Week | Credits |
|------|----------|--------|--------------|------------|---------|
|------|----------|--------|--------------|------------|---------|

|                         |                             | No.     |                                                                                     | (Theory + Lab) |     |
|-------------------------|-----------------------------|---------|-------------------------------------------------------------------------------------|----------------|-----|
| 4 <sup>th</sup><br>Year | 1 <sup>st</sup><br>Semester | STA455L | Design & Analysis<br>of Experiments – II<br>Lab (Pre-requisites<br>STA351, STA351L) | 0 + 4          | 2.0 |

**Rationale of the Course:** Solving the problems on advanced design of experiments.

#### Objectives

- Make the students conduct confounded factorial design of experiments,
- Help the students perform incomplete block design of experiments,
- Helping the students able to analyze asymmetric factorial designs,
- Make the students perform analysis of covariance.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Apply the confounded factorial experiment and advanced experimental designs;  
 CLO2 Analyze data on experiments with incomplete blocks;  
 CLO3 Analyze asymmetrical experiments;  
 CLO4 Fit ANCOVA models.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          | √        | √        |          | √        |          | √        | √        |          | √         |
| CLO2        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO3        |          |          | √        |          | √        |          | √        | √        |          | √         |
| CLO4        |          |          | √        |          | √        |          | √        | √        |          | √         |

#### Contents of the Course

Total, partial and simultaneous confounding, fractionally replicated factorial experiment, intra block and inter block analysis of BIBD, analysis of split-plot design, split-split plot design, strip-plot design and nested design, analysis of covariance.

#### Main Texts

1. Montgomery D. C., (2020), Design and Analysis of Experiments, 10<sup>th</sup> Edition, Wiley, NY
2. Das M. N. & Giri N. C., (2017), Design and Analysis of Experiments, 3<sup>rd</sup> Edition, New Age International, Delhi
3. Sahai H. & Ageel, M. I., (2000), The Analysis of Variance: Fixed. Random and Mixed Models, MA: Birkhauser, Boston

#### Reference Books

1. Bhuyan M. R., Fundamentals of Experimental Design, 2<sup>nd</sup> Edition, Book World Publications, Dhaka

2. Gomez K. A. & Gomez A. A., Statistical Procedures for Agricultural Research, 2<sup>nd</sup> Edition, Wiley, NY
3. Kempthorne O., The Design and Analysis of Experiment, Reprint Edition, Wiley, NY

| Year                    | Semester                    | Course<br>No. | Course Title                                                   | Hours/Week<br>(Theory +<br>Lab) | Credits |
|-------------------------|-----------------------------|---------------|----------------------------------------------------------------|---------------------------------|---------|
| 4 <sup>th</sup><br>Year | 1 <sup>st</sup><br>Semester | STA457        | Sampling Techniques<br>– II (Pre-requisite<br>STA154, STA154L) | 3 + 0                           | 3.0     |

**Rationale of the Course:** Acquiring knowledge to design and implement complex sample surveys.

#### Objectives

- Acquaint students with the concepts and solid knowledge of cluster sampling, multistage sampling, double sampling, and sampling on two or more occasions,
- Make students understand sampling and non-sampling errors and consequences of such errors,
- Foster the analytical and critical thinking ability to outline and carry out various complex surveys,
- Familiarize with large-scale surveys used in Bangladesh.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Distinguish between sampling with equal and unequal probability;  
 CLO2 Describe and discriminate cluster sampling, multistage sampling, double sampling, and sampling on two or more occasions  
 CLO3 Differentiate between sampling and non-sampling errors;  
 CLO4 Produce appropriate estimation of population means, and totals along with their standard errors under various sampling techniques;  
 CLO5 Design and implement appropriate sample surveys in various social, economic, agricultural, industrial, and health sectors.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          |          | √        |          | √        |          |          | √         |
| CLO2        | √        | √        |          |          | √        |          | √        |          |          | √         |
| CLO3        | √        | √        |          |          | √        |          | √        |          |          | √         |
| CLO4        | √        | √        |          |          | √        |          | √        |          |          | √         |
| CLO5        | √        | √        |          |          | √        |          | √        |          |          | √         |

#### Contents of the Course

Sampling with unequal probability, Horvitz-Thompson estimator and its standard error. Brewer and Durbin's methods of selection of sample of size 2. Raj, Murthy, Rao-Hartley and Cochran and Samford's methods of selection. PPS systematic selection. Estimation and standard errors.

Multi-stage sampling: two and three stage sampling – equal and unequal clusters. Selection of units with equal and unequal probability with or without replacement. Self-weighting estimates.

Double sampling with PPS selection: double sampling for stratification, ratio, regression and difference estimations, repetitive surveys. Sampling on two or more occasions.

Sampling errors and non-sampling errors: different methods of estimating non-sampling errors. Nonresponse, interviewer's bias, interpenetrating subsamples. Familiarity with recent sample surveys in Bangladesh.

Large-scale surveys – DHS, HIES and SVRS.

### Main Texts

1. Cochran W. G., (1977), Sampling Techniques, 3<sup>rd</sup> Edition, John Wiley, NY
2. Lohr S. L., (2010), Sampling: Design and Analysis, 2<sup>nd</sup> Edition, MPS Limited, A Macmillan Company, USA

### Reference Books

1. Des Raj, (1968), Sampling Theory, Tata McGraw Hill, Delhi
2. Islam M. N., (2005), An Introduction to Sampling Methods, 1<sup>st</sup> Edition, Book World, Dhaka.
3. Kish L., (1968), Survey Sampling, Wiley, 1<sup>st</sup> Edition, NY
4. Latest Reports of BDHS, HIES, SVRS
5. Singh D., & Chaudhary F. S., (1986), Theory and Analysis of Sample Survey Designs, John Wiley & Sons
6. Sukhatme P. V., (1984), Sampling Theories and Surveys with Applications, 3<sup>rd</sup> Edition, Iowa State University Press, USA
7. United Nations Handbook on Surveys

| Year                 | Semester                 | Course No. | Course Title                                                 | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------------------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 1 <sup>st</sup> Semester | STA457L    | Sampling Techniques - II Lab (Pre-requisite STA154, STA154L) | 0 + 2                     | 1.0     |

**Rationale of the Course:** Apply acquired knowledge to complex sample surveys.

### Objectives

- Help the students to draw sample using double sampling, two-stage sampling and PPS sampling,
- Make the students able to estimate population totals, population means and standard errors under double sampling, two-stage sampling and PPS sampling.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Perform complex sampling designs;  
 CLO2 Compute population totals, population means and standard errors under double sampling, two-stage sampling and PPS sampling;  
 CLO3 Find self-weighting estimates.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       | √     | √     |       | √     |       | √     | √     |       | √      |
| CLO2        |       |       | √     |       | √     |       | √     | √     |       | √      |
| CLO3        |       |       | √     |       | √     |       | √     | √     |       | √      |

**Contents of the Course:** Estimates and standard errors of estimates for sample selected with unequal probabilities, Two or more stage sampling (equal and unequal size clusters), PPS sampling, double sampling, self-weighting estimates.

### Main Texts

1. Cochran W. G., (1977), Sampling Techniques, 3<sup>rd</sup> Edition, John Wiley, NY
2. Lohr S. L., (2010), Sampling: Design and Analysis, 2<sup>nd</sup> Edition, MPS Limited, A Macmillan Company, USA

### Reference Books

1. Des Raj, (1968), Sampling Theory, Tata McGraw Hill, Delhi
2. Islam M. N., (2005), An Introduction to Sampling Methods, 1<sup>st</sup> Edition, Book World, Dhaka.
3. Kish L., (1968), Survey Sampling, Wiley, 1<sup>st</sup> Edition, NY
4. Latest Reports of BDHS, HIES, SVRS
5. Singh D., & Chaudhary F. S., (1986), Theory and Analysis of Sample Survey Designs, John Wiley & Sons
6. Sukhatme P. V., (1984), Sampling Theories and Surveys with Applications, 3<sup>rd</sup> Edition, Iowa State University Press, USA
7. United Nations Handbook on Surveys

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 1 <sup>st</sup> Semester | STA400A    | Presentation & Viva-voce | 0 + 0                     | 1.0     |

**Rationale of the Course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Develop verbal communication and presentation skills;  
 CLO2 Communicate their learning effectively and appropriately to formal audiences;  
 CLO3 Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;

- CLO4 Prepare for professional oral examinations which is useful to enhance employment interview skills;
- CLO5 Demonstrate their ability to participate in academic discussion.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO2        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO3        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO4        | √        | √        |          |          | √        |          |          | √        | √        | √         |
| CLO5        | √        | √        |          |          | √        |          |          | √        | √        | √         |

**Contents of the Course:**Comprehensive contents of all the underlying courses of the semester.

#### Main Text

- Textbooks referred for all the underlying courses of the semester.

#### Reference Books

- Reference books referred for all the underlying courses of the semester.

#### Fourth Year Second Semester Course Details

| Year                 | Semester                 | Course No. | Course Title          | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA452     | Multivariate Analysis | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge of the analysis and interpretation of multivariate techniques.

#### Objectives

- To facilitate necessary knowledge about multivariate theory,
- To provide knowledge of statistical inference about multivariate means including hypothesis testing, confidence ellipsoid calculation and different types of confidence intervals estimation.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Understand non-central sampling distributions;
- CLO2 - Explain the distribution of quadratic forms;
- CLO3 - Understand multivariate normal distribution;
- CLO4 - Describe multivariate sampling distributions;
- CLO5 - Fit multivariate linear models.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO2        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO3        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO4        | √        |          | √        | √        |          | √        | √        |          |          | √         |
| CLO5        | √        |          | √        | √        |          | √        | √        |          |          | √         |

#### Contents of the Course

**Non-central distributions:** Non-central  $\chi^2$ , non-central t and non-central F distributions and their properties.

**Distribution of quadratic forms:** Distribution of general quadratic form, properties, expected values, moment and moment generating function, Cochran's theorem.

**Multivariate normal distribution:** Derivation of multivariate normal distribution, marginal, conditional, moments, moment generating functions, and characteristic function. Properties of multivariate normal distribution.

**Multivariate sampling distributions:** Hotelling's  $T^2$  distribution, Mahalanobish  $D^2$  distribution, Wishart distribution. Tests for covariance and correlation patterns and multivariate normality. Simulation of multivariate normal variate.

**Multivariate linear models:** Multivariate linear regression, MANOVA, MANCOVA, covariance selection, conditional Gaussian distribution and conditional independence graph.

### Main Texts

1. Johnson R. A. & Wichern D. W., (2015), Applied Multivariate Statistical Analysis, 6<sup>th</sup> Edition, Pearson Prentice Hall, NJ
2. Rencher A. C., Christensen F., (2012), Methods of Multivariate Analysis, 3<sup>rd</sup> Edition, John Wiley & Sons Inc, NY

### Reference Books

1. Anderson T. W., An Introduction to Multivariate Analysis, Wiley and Sons, NY
2. Graybill F. A., An Introduction to Linear Statistical Models, Vol-1, 2<sup>nd</sup> Edition, McGraw Hill, NY
3. Cox & Hinkley, Theoretical Statistics, Chapman and Hall, UK

| Year                 | Semester                 | Course No. | Course Title              | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|---------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA452L    | Multivariate Analysis Lab | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge of the analysis and interpretation of real-life multivariate data.

### Objectives

- Facilitate necessary skills to draw multivariate random samples,
- Acquaint students with the hypothesis testing of multivariate means,
- Helping the students to develop the ability to apply multivariate linear regression model and test for goodness of fit.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Apply multivariate normal distribution;

CLO2 - Use multivariate sampling distributions;

CLO3 - Analyze multivariate linear models.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       |       | √     | √     |       | √     | √     |       |       | √      |
| CLO2        |       |       | √     | √     |       | √     | √     |       |       | √      |
| CLO3        |       |       | √     | √     |       | √     | √     |       |       | √      |

### Contents of the Course

Simulation of multivariate normal variate. Tests of mean vectors by Hotelling's  $T^2$  and Mahalanobish  $D^2$ ; Tests for covariance and correlation patterns and multivariate normality. Estimation of multivariate linear regression and construction of MANOVA.

### Main Text

- Johnson R. A. & Wichern D. W., (2015), Applied Multivariate Statistical Analysis, 6<sup>th</sup> Edition, Pearson Prentice Hall, NJ

### Reference Books

1. Rencher A. C., Christensen F., (2012), Methods of Multivariate Analysis, 3<sup>rd</sup> Edition, John Wiley & Sons Inc, NY
2. Graybill F. A., An Introduction to Linear Statistical Models, Vol-1, 2<sup>nd</sup> Edition, McGraw Hill, NY

| Year                 | Semester                 | Course No. | Course Title                   | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA454     | Biostatistics and Epidemiology | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge to analyze data produced in biological sciences.

### Objectives

- Acquaint students with the concepts of Biostatistics and Epidemiology,
- Help students conceptualize basic theories in lifetime distributions, estimation of survival functions, concepts of incomplete data and estimation of survival probabilities,
- Provide students with the tools and strategies of epidemiological investigation studies.

**Course Learning Outcomes:** At the end of the course, students will be able to –

CLO Explain basic concepts of Biostatistics and Epidemiology;

CLO Describe methods and analytical tools for survival data;

CLO Illustrate several epidemiological studies with layouts;

CLO Analyze survival data in different fields, especially medical and engineering sectors;

CLO Analyze data produced in life sciences and epidemiological studies.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     | √     |       |       | √     |       | √     |       |       | √      |
| CLO2        | √     | √     |       |       | √     |       | √     |       |       | √      |
| CLO3        | √     | √     |       |       | √     |       | √     |       |       | √      |
| CLO4        | √     | √     |       |       | √     |       | √     |       |       | √      |
| CLO5        | √     | √     |       |       | √     |       | √     |       |       | √      |

### Contents of the Course

**Basic quantities:** Concept of survival data, application and challenges of survival data in different fields, history of survival analysis and its progress, censoring: type – I, type – II and random censoring, truncation, lifetime distribution, survival function, hazard function, interrelationships, mean residual life function, median life time.

**Nonparametric methods:** Kaplan–Meier (product-limit), Nelson–Aalen estimators, Life-table (or actuarial) method, Log-rank and Wilcoxon test, estimation of survival function, hazard function; reduced sample method, estimation and standard error.

**Parametric and semi-parametric methods:** Construction of likelihood function for censored and complete data, inference procedure for exponential and Weibull distributions under complete and censored data. Basic concept of Cox proportional hazard model.

**Epidemiologic concept:** Overview of important historical development of epidemiology, basic terminology and principles used in epidemiology. Sources of data of community health: census, vital statistics and morbidity data. Study designs: case-control, cohort, prospective, retrospective, longitudinal studies. Basic concept of causal inference.

**Measure of effect and measures of association:** Incidence, prevalence, sensitivity and specificity. ROC curve. Effect measure, measures of association, standard measures, prevalence ratio, relative risk, attributable risk, odds ratio, standard errors of estimates for different types studies.

**Models:** Correlated proportion, McNemar test, logistic and Poisson regression models, correlated data, basic concepts of linear mixed models.

#### Main Texts

1. Klein J. P. & Moeschberger M. L., (2003), Survival Analysis – Techniques for Censored and Truncated data, 2<sup>nd</sup> Edition, Springer-Verlang, New York
2. Kleinbaum D G, *et al* (1982), Epidemiologic Research: Principles and Quantitative Methods, John Wiley & Sons, USA
3. Rothman K. J., (2012), Epidemiology: An Introduction, 2<sup>nd</sup> Edition, Oxford University Press, UK

#### Reference Books

1. Bonita R *et al* (2006), Basic Epidemiology, WHO
2. Collett D (2014), Modelling Survival Data in Medical Research, 3<sup>rd</sup> Edition, Chapman and Hall, Florida
3. Cox D R & Oakes D (1984), Analysis of Survival Data, Reprint Edition, Chapman & Hall/CRC Press, NY
4. Elandt-Johnson R C & Johnson N L (1999), Survival Models and Data Analysis, Wiley Inter Science, USA
5. Lawless J. F., (2002), Statistical Models and Methods for Lifetime Data, 2<sup>nd</sup> Edition, John Wiley & Sons, USA
6. Kalbfleisch J D & Prentice R L (2011), The Statistical Analysis of Failure Time Data, 2<sup>nd</sup> Edition, John Wiley & Sons, USA
7. Kleinbaum, David G., Klein, Mitchel (2005), Survival Analysis: A Self-Learning Text, 3<sup>rd</sup> Edition, Springer-Verlang, New York
8. Rothman K J & Greenland S (2012), Modern Epidemiology, 3<sup>rd</sup> Edition, Lippincott Williams and Wilkins, USA
9. Verbeke G. & Molenberghs G., (2000), Linear Mixed Models for Longitudinal Data, Springer-Verlag, New York

| Year | Semester | Course No. | Course Title | Hours/Week (Theory + Lab) | Credits |
|------|----------|------------|--------------|---------------------------|---------|
|------|----------|------------|--------------|---------------------------|---------|

|                         |                             |         |                                       |       |     |
|-------------------------|-----------------------------|---------|---------------------------------------|-------|-----|
| 4 <sup>th</sup><br>Year | 2 <sup>nd</sup><br>Semester | STA454L | Biostatistics and<br>Epidemiology Lab | 0 + 4 | 2.0 |
|-------------------------|-----------------------------|---------|---------------------------------------|-------|-----|

**Rationale of the Course:** Apply acquired knowledge to analyze data produced in life sciences and epidemiological studies.

#### Objectives

- Help students apply lifetime distributions, estimate survival functions and calculate survival probabilities,
- Provide students necessary skills to estimate various epidemiological measures.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Analyze survival data using computer software;

CLO2 - Analyze epidemiological data with proper interpretation;

CLO3 - Test correlated proportions.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO<br>1 | PLO<br>2 | PLO<br>3 | PLO<br>4 | PLO<br>5 | PLO<br>6 | PLO<br>7 | PLO<br>8 | PLO<br>9 | PLO<br>10 |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| CLO1        |          | √        | √        |          | √        |          | √        | √        |          | √         |
| CLO2        |          | √        | √        |          | √        |          | √        | √        |          | √         |
| CLO3        |          | √        | √        |          | √        |          | √        | √        |          | √         |

#### Contents of the Course

Estimation of survival probabilities using non-parametric methods for complete and censored cases. Identification of parametric models for survival data, estimation of parameters and hypothesis testing for exponential and Weibull distribution with complete and censored samples.

Computation of incidence, prevalence, sensitivity and specificity. Measures of association, estimation of relative risk, attributable risk and odds ratio. Computation of standard errors of estimates for different types of epidemiological studies.

Application of correlated proportion, McNemar test, logistic regression model and linear mixed models.

#### Main Texts

1. Klein J. P. & Moeschberger M. L., (1997), Survival Analysis – Techniques for Censored and Truncated data, Springer-Verlang, New York
2. Lawless J. F., (2002), Statistical Models and Methods for Lifetime Data, 2<sup>nd</sup> Edition, John Wiley & Sons, USA
3. Rothman K. J., (2012), Epidemiology: An Introduction, 2<sup>nd</sup> Edition, Oxford University Press, UK

#### Reference Books

1. Bonita R *et al* (2006), Basic Epidemiology, WHO
2. Collett D (2014), Modelling Survival Data in Medical Research, 3<sup>rd</sup> Edition, Chapman and Hall, Florida
3. Cox D R & Oakes D (1984), Analysis of Survival Data, Reprint Edition, Chapman & Hall/CRC Press, NY
4. Elandt-Johnson R C & Johnson N L (1999), Survival Models and Data Analysis, Wiley Inter Science, USA

5. Kalbfleisch J D & Prentice R L (2011), The Statistical Analysis of Failure Time Data, 2<sup>nd</sup> Edition, John Wiley & Sons, USA
6. Kleinbaum D G, *et al* (1982), Epidemiologic Research: Principles and Quantitative Methods, John Wiley & Sons, USA
7. Kleinbaum, David G., Klein, Mitchel (2005), Survival Analysis: A Self-Learning Text, 3<sup>rd</sup> Edition, Springer-Verlag, New York
8. Pocock S J (1985), Clinical Trials: A Practical Approach, Wiley, NY
9. Rothman K J & Greenland S (2012), Modern Epidemiology, 3<sup>rd</sup> Edition, Lippincott Williams and Wilkins, USA
10. Verbeke, G. and Molenberghs, G. (2000) Linear Mixed Models for Longitudinal Data, Springer-Verlag, New York

| Year                 | Semester                 | Course No. | Course Title                                              | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------------------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA456     | Generalized Linear Models (Pre-requisite STA358, STA358L) | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on models those follows exponential family of distributions.

#### Objectives

- Acquaint students with the concepts of model fitting and adequacy checking,
- To facilitate necessary knowledge on sampling distribution of score statistics, maximum likelihood estimators, deviance, and likelihood ratio statistics,
- Provide knowledge of exponential family of distributions, general and generalized linear models, and various link functions,
- Foster the analytical and critical thinking ability for analyzing data that come from normal as well as other distributions.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Demonstrate model fitting strategies;  
 CLO2 - Derive sampling distributions of score statistics, MLEs, deviance, log-likelihood ratio statistics;  
 CLO3 - Explain exponential family of distributions;  
 CLO4 - Compare and contrast between general and generalized linear models;  
 CLO5 - Carry out tests of hypotheses related to GLMs;  
 CLO6 - Assess the adequacy and fit of GLMs  
 CLO7 - Discriminate quasi-likelihood and likelihood function and apply them appropriately for fitting model.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       |       | √     | √     |       |       | √      |
| CLO2        | √     |       | √     |       |       | √     | √     |       |       | √      |
| CLO3        | √     |       | √     |       |       | √     | √     |       |       | √      |
| CLO4        | √     |       | √     |       |       | √     | √     |       |       | √      |
| CLO5        | √     |       | √     |       |       | √     | √     |       |       | √      |

|      |   |  |   |  |  |   |   |  |  |   |
|------|---|--|---|--|--|---|---|--|--|---|
| CLO6 | √ |  | √ |  |  | √ | √ |  |  | √ |
| CLO7 | √ |  | √ |  |  | √ | √ |  |  | √ |

#### Contents of the Course

Introduction to the concepts of modeling. model fitting: examples, some principles of statistical modeling (exploratory data analysis), model formulation, parameter estimation, residuals and model checking), estimation and tests based on specific problems

Sampling distribution for score statistics, MLEs, deviance; log-likelihood ratio statistic.

Exponential family and generalized linear models (GLM) (Bernoulli, binomial, Poisson, exponential, gamma, normal, *etc.*)

Properties of distributions in the exponential family, expected value, variance, expected value and variance of score statistic, examples for various distributions.

Components of generalized linear models – random, systematic and link functions, Poisson regression.

Maximum likelihood estimation using chain rules, random component, mean and variance of the outcome variable, variance function, dispersion parameter, applications.

Systematic component and link function: identity link, logit link, log link, parameter estimation.

Score function and information matrix, estimation using the method of scoring, iteratively reweighted least squares.

Inference procedures, deviance for logit, identity, log link functions, scaled deviance, sampling distributions, hypothesis testing.

Generalized Pearson chi-square statistic, residuals for GLM, Pearson residual, Anscombe residuals.

Logit link function, iteratively reweighted least squares, tests; nominal and ordinal logistic regression.

Goodness of fit tests, Hosmer-Lemeshow test, pseudo-R square, AIC and BIC.

Quasi likelihood, construction of quasi likelihood for correlated outcomes, parameter estimation, variance-covariance of estimators, estimation of variance function.

Quasi likelihood estimating equations, comparison between likelihood and quasi likelihood methods, generalized estimating equations (GEE) for repeated measures data, repeated measures models for normal data (e.g. Linear Mixed Effect Models), repeated measures models for non-normal data (e.g. Generalized Linear Mixed Effect Models), working correlation matrix, robust variance estimation or information sandwich estimator, hypothesis testing.

#### Main Text

- Dobson A. J. & Barnett A. G., (2008), An Introduction to Generalized Linear Models, 3<sup>rd</sup> Edition, Chapman and Hall, Florida

#### Reference Books

1. Agresti A., Categorical Data Analysis, 3<sup>rd</sup> Edition, Wiley, NY
2. Hosmer D. W., & Lemeshow S., Applied Logistic Regression, 2<sup>nd</sup> Edition, Wiley, NY

- McCullagh P. & Nelder J. A., Generalized Linear Models, 2<sup>nd</sup> Edition, Chapman and Hall, UK
- Molenberghs G. & Verbeke G., (2005), Models for Discrete Longitudinal Data, Springer
- Verbeke G. & Molenberghs G., (2000), Linear Mixed Models for Longitudinal Data, Springer

| Year                 | Semester                 | Course No. | Course Title                                                  | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|---------------------------------------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA456L    | Generalized Linear Models Lab (Pre-requisite STA358, STA358L) | 0 + 4                     | 2.0     |

**Rationale of the Course:** Apply acquired knowledge on models those follows exponential family of distributions.

#### Objectives

- Make the students to fit model and checking adequacy,
- Provide the necessary skills to apply exponential family of distributions,
- Provide the necessary skills to apply general and generalized linear models,
- Make the students able to apply generalized estimating equations and generalized mixed effect models,

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Compute score statistics, deviance, log-likelihood ratio statistics;  
 CLO2 - Fit general and generalized linear models;  
 CLO3 - Perform tests of hypotheses related to GLMs;  
 CLO4 - Perform generalized estimating equations (GEE);  
 CLO5 - Analyze generalized linear mixed effect models.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       |       | √     |       |       | √     | √     | √     |       | √      |
| CLO2        |       |       | √     |       |       | √     | √     | √     |       | √      |
| CLO3        |       |       | √     |       |       | √     | √     | √     |       | √      |
| CLO4        |       |       | √     |       |       | √     | √     | √     |       | √      |
| CLO5        |       |       | √     |       |       | √     | √     | √     |       | √      |

#### Contents of the Course

Compute score statistics, deviance; log-likelihood ratio statistic.  
 Exponential family and generalized linear models (GLM) (Bernoulli, binomial, Poisson, exponential, gamma, normal, etc.).  
 Expected value and variance of score statistic, Link functions: various link functions such as identity link, logit link, log link. Parameter estimation. Inference procedures, hypothesis testing, Goodness of fit tests. Linear mixed effect model, generalized estimating equations (GEE), generalized linear mixed effect model.

#### Main Text

- Dobson A. J. & Barnett A. G., (2008), An Introduction to Generalized Linear Models, 3<sup>rd</sup> Edition, Chapman and Hall, Florida

#### Reference Books

- Agresti A., Categorical Data Analysis, 3<sup>rd</sup> Edition, Wiley, NY
- Hosmer D. W., & Lemeshow S., Applied Logistic Regression, 2<sup>nd</sup> Edition, Wiley, NY
- McCullagh P. & Nelder J. A., Generalized Linear Models, 2<sup>nd</sup> Edition, Chapman and Hall, UK
- Molenberghs G. & Verbeke G., (2005), Models for Discrete Longitudinal Data, Springer
- Verbeke G. & Molenberghs G., (2000), Linear Mixed Models for Longitudinal Data, Springer

| Year                 | Semester                 | Course No. | Course Title         | Hours/Week (Theory + Lab.) | Credits |
|----------------------|--------------------------|------------|----------------------|----------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA458     | Research Methodology | 2 + 0                      | 2.0     |

**Rationale of the Course:** Acquiring in depth knowledge of research methodology.

#### Objectives

- Acquaint students with basic concepts of research and its methodologies,
- Provide knowledge of selecting and define appropriate research problems,
- Facilitate necessary knowledge about writing research proposal, research report and thesis,
- To enhancing the skill on conducting research project in groups.

**Course Learning Outcomes:** At the end of the course, students will be able to -

- CLO1 - Critically analyze research methodologies identified in existing literature;  
 CLO2 - Develop a comprehensive research methodology for a research question;  
 CLO3 - Write good research proposal;  
 CLO4 - Carry out a research project independently;  
 CLO5 - Conduct research in collaboration;  
 CLO6 - Prepare research report.

#### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       | √     | √     |       | √     |       | √     | √     |       | √      |
| CLO2        |       | √     | √     |       | √     |       | √     | √     |       | √      |
| CLO3        |       | √     | √     |       | √     |       | √     | √     |       | √      |
| CLO4        |       | √     | √     |       | √     |       | √     | √     |       | √      |
| CLO5        |       | √     | √     |       | √     |       | √     | √     |       | √      |

|      |  |   |   |  |   |  |   |   |  |   |
|------|--|---|---|--|---|--|---|---|--|---|
| CLO6 |  | √ | √ |  | √ |  | √ | √ |  | √ |
|------|--|---|---|--|---|--|---|---|--|---|

### Contents of the Course

Elements of research: concepts, definitions and scope of research. Research question, target population and study population. Research methods and methodology, research ethics, desirable qualities of research, research question, research objectives, research hypotheses, operational definition.

Research ideas: role of literature review. Inductive approach, deductive approach, complementary of inductive and deductive approach, wheel of science.

Research approaches and types: quantitative and qualitative approaches of research. Idea about various types of research under qualitative and quantitative approaches according to different criteria.

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.

Detailed study of important research designs: exploratory studies – secondary data analysis, experience survey, pilot study, case study, focus group discussion. Descriptive studies – cross-sectional, longitudinal, trend, panel study, baseline study, impact assessment, feasibility study designs. Causal studies – comparative, case-control, cohort.

Experimental studies: concepts of randomization, grouping, matching, advantages and disadvantages over non-experimental designs, validity in experimentation. Study on experimental research designs – pre-experimental, true-experimental and quasi-experimental.

Sample design: choice of correct sampling methods and sample size determination.

Data gathering: quantitative data collection techniques – interview method, mail method, telephone surveys; qualitative methods of data collection – observation, in-depth interviews, case studies, focus group discussions. Key informant interview, participatory rural appraisal.

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.

Idea about planning and implementation of a research study: time and financial budgeting, logistics of data collection, recruitment and training of the enumerators, field work supervision and quality control of data.

Data processing and analysis: editing, coding, data entry, validation check, imputation of variables, tabulation plan, data analysis.

Reliability and validity in measurements: initiation of model building, measurement error, test for sound measurement, reliability and its measurements, validity and its types, measurements of validity; stability of the model over the population, 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.

Research proposal: request for proposal, term of reference, components of a proposal, evaluation of proposal.

### Main Texts

1. Kothari C. R., (2013), Research Methodology - Methods and Techniques, 3<sup>rd</sup> Edition, New Age, New Delhi
2. Trochim W M K, Research Methods – Knowledge Base, <https://www.socialresearchmethods.net/kb/>
3. Akand M. A. S., (2019), Research Methodology – A Complete Direction for Learners, 2nd Edition, Akanda & Sons, Academic Publishers, Dhaka

### Reference Books

1. Islam M. N., An Introduction to Research Methods, Mullick & Brothers, Dhaka
2. Malhotra N. K., Marketing Research – An Applied Orientation, 5<sup>th</sup> Edition, Prentice Hall of India, New Delhi
3. Palys T., Research Decisions – Quantitative and Qualitative Perspectives, 2<sup>nd</sup> Edition, International Thomson Publishing

| Year                 | Semester                 | Course No. | Course Title                      | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-----------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA460     | Project (Mandatory course STA458) | 30 Days                   | 2.0     |

**Rationale of the Course:** Developing skills on application of the statistical knowledge acquired throughout the undergraduate program.

### Objectives

- To facilitate necessary skills about hands-on experience of conducting a research project,
- Foster the analytical and critical thinking ability to apply statistical methods appropriately.

**Course Learning Outcomes:** At the end of the course, students will be able to -

CLO1 - Design a research project;

CLO2 - Write an appropriate research proposal;

CLO3 - Develop suitable questionnaire for collecting necessary primary data;

CLO4 - Demonstrate ability to design a database and perform data management and data processing;

CLO5 - Perform necessary data analysis;

CLO6 - Write a research report and give an effective oral presentation.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        |       | √     | √     |       | √     |       | √     | √     | √     | √      |
| CLO2        |       | √     | √     |       | √     |       | √     | √     | √     | √      |
| CLO3        |       | √     | √     |       | √     |       | √     | √     | √     | √      |
| CLO4        |       | √     | √     |       | √     |       | √     | √     | √     | √      |
| CLO5        |       | √     | √     |       | √     |       | √     | √     | √     | √      |
| CLO6        |       | √     | √     |       | √     |       | √     | √     | √     | √      |

### Contents of the Course

Students will in consultation with assigned teachers select project topics.

**Evaluation:** Every student will have to submit research report to the department through assigned teachers. The reports will be examined by the assigned teachers against 30% marks, by another examiner against 30% marks. The oral presentation of reports for examinations by the examination committee will carry another 40% marks. Results will be processed by the examination committee.

| Year                 | Semester                 | Course No. | Course Title             | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|--------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA400B    | Presentation & Viva-voce | 0 + 0                     | 1.0     |

**Rationale of the Course:** Assessing students' comprehensive knowledge on basic concepts of the courses learned in the current semester.

### Objectives

- Help students to gain confidence in their own ability to present and explain the basic concepts of the courses.
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Develop verbal communication and presentation skills;
- CLO2 Communicate their learning effectively and appropriately to formal audiences;
- CLO3 Explain key concepts of the courses, interpret key terms, and justify their arguments logically to non-statisticians;
- CLO4 Prepare for professional oral examinations which is useful to enhance employment interview skills;
- CLO5 Demonstrate their ability to participate in academic discussion.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO2        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO3        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO4        | √     | √     |       |       | √     |       |       | √     | √     | √      |
| CLO5        | √     | √     |       |       | √     |       |       | √     | √     | √      |

**Contents of the Course:**Comprehensive contents of all the underlying courses of the semester.

### Main Text

- Textbooks referred for all the underlying courses of the semester.

### Reference Books

- Reference books referred for all the underlying courses of the semester.

### Optional Course Details

| Year                 | Semester                 | Course No. | Course Title                 | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA491     | Comprehensive – I (Optional) | 3 + 0                     | 3.0     |

**Rationale of the Course:** Reviving foundation of the students on statistical tools and techniques for collecting and analyzing data, and interpretation of the findings.

### Objectives

- Make the students understand the statistical tools and techniques for data collection and analysis,
- Helping the students to apply statistical techniques in real field.

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Gather widespread knowledge on descriptive statistical tools, probability, probability distributions, and sampling distributions;
- CLO2 Select appropriate sampling techniques and determination of sample size in real situation;
- CLO3 Estimate the parameters using point estimation and interval estimation techniques;
- CLO4 Develop a regression model and predict;
- CLO5 Perform tests of hypothesis of the population parameters and non-parametric tests;
- CLO6 Layout and analyze experimental design;
- CLO7 Estimate demographic parameters.

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO2        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO3        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO4        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO5        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO6        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO7        | √     |       | √     |       | √     |       | √     |       |       | √      |

### Contents of the Course

Core concepts from STA151, STA152, STA154, STA252, STA253, STA351, STA353, STA358, STA452, STA453.

### Reference Books

1. Gupta S. C. & Kapoor V. K., (2000), Fundamentals of Mathematical Statistics, 10<sup>th</sup> Revised Edition, Sultan Chand and Sons, New Delhi, India
2. Islam M. N., (2006), Introduction to Statistics and Probability, 3rd Edition, Book World, Dhaka

- Mostafa, M. G., (1989), Methods of Statistics, Karim press and publication, Dhaka Bangladesh
- Ross S. M., (2010), Introductory Statistics, 3<sup>rd</sup> Edition, Academic Press, USA
- Ross S. M., (2018), A First Course in Probability, 9<sup>th</sup> Edition, Academic Press, NY
- Roy M. K., (2011), Fundamentals of Probability and Probability Distributions, 8<sup>th</sup> Edition, ROMAX Publications, Chittagong

| Year                 | Semester                 | Course No. | Course Title                  | Hours/Week (Theory + Lab) | Credits |
|----------------------|--------------------------|------------|-------------------------------|---------------------------|---------|
| 4 <sup>th</sup> Year | 2 <sup>nd</sup> Semester | STA492     | Comprehensive – II (Optional) | 3 + 0                     | 3.0     |

**Rationale of the Course:** Acquiring knowledge on application of statistical methods used in medical/health research.

### Objectives

- Make the students to demonstrate knowledge on descriptive statistics and probability,
- Helping the students to learn basic of epidemiological study designs, their measures and diagnostic tests,
- Equip different tests of independent and correlated categorical variables,
- Helping the students understand the theory of regression (multiple, logistic and Poisson regression) analysis,
- Provide knowledge on survival analysis (parametric and non-parametric),

**Course Learning Outcomes:** At the end of the course, students will be able to –

- CLO1 Explore descriptive statistics, conditional probability and Bayes' theorem;  
 CLO2 Calculate different epidemiological measures;  
 CLO3 Apply regression model (linear, logistic, and Poisson);  
 CLO4 Use lifetime distributions, non-parametric survival analysis and Cox-proportional Hazards model;

### Mapping CLOs to PLOs

| CLO/<br>PLO | PLO 1 | PLO 2 | PLO 3 | PLO 4 | PLO 5 | PLO 6 | PLO 7 | PLO 8 | PLO 9 | PLO 10 |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| CLO1        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO2        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO3        | √     |       | √     |       | √     |       | √     |       |       | √      |
| CLO4        | √     |       | √     |       | √     |       | √     |       |       | √      |

### Contents of the Course

Descriptive statistics, probability: conditional probability and Bayes' theorem, study designs: case-control, cohort, prospective, retrospective, longitudinal studies, diagnostic tests: sensitivity and specificity, and ROC curve, Statistical methods: contingency tables: risks, odds ratio, chi-square test, Mantel-Haenszel test, McNemar test, diagnostic consistency: intra- and inter-rater agreement, linear and

logistic regression, Poisson regression models, survival analysis, bias and confounding.

**Delivery Modes:** Contact teaching: Students will use the statistical software SPSS/R/STATA. All course topics above will first be learned and implemented without software, and then will be applied to large data sets with the use of SPSS/R/STATA.

### Main Texts

- Klein J. P. & Moeschberger M. L., (2003), Survival Analysis – Techniques for Censored and Truncated data, 2<sup>nd</sup> Edition, Springer-Verlang, New York
- Rothman K. J., (2012), Epidemiology: An Introduction, 2<sup>nd</sup> Edition, Oxford University Press, UK
- Webb P. and Bain C., (2011), Essential Epidemiology: An introduction for Students and Health Professionals. Cambridge University Press.

### Reference Books

- Collett D, (2014), Modelling Survival Data in Medical Research, 3<sup>rd</sup> Edition, Chapman and Hall, Florida
- Harris M. & Taylor G., (2008) Medical Statistics Made Easy, 2<sup>nd</sup> Edition, Scion Publishing Ltd, UK.
- Islam M. N., (2006), Introduction to Statistics and Probability, 3<sup>rd</sup> Edition, Book World, Dhaka

## Ordinance for the Graduate Program at SUST

Formation of Graduate Study Committee (GSC) will be the prerequisite to start a Graduate program in any Discipline. The GSC will be headed by the Head of the Discipline/ Institute consisting of all professors/Associate Professors of the discipline concerned with a minimum number of 3 professors/Associate Professors. When Professors and Associate Professors are not available in the discipline, the required number of Professors, Associate Professors will be included from the relevant Discipline / Institute by the proposal of the Board of Advanced Studies (BAS) and the Academic council.

### 1. Introduction

- 1.1 The graduate program consists of Masters (General), Masters (Thesis), M.Sc. (Engineering), Masters of Philosophy (M.Phil.) and Ph.D. degrees.
- 1.2 A graduate program may also be offered by a discipline in some specified field in collaboration with other disciplines.
- 1.3 Any student with (i) 4 year Bachelors degree (ii) 3-year Bachelor and 1-year Masters Degree or (iii) 5-year Bachelor of Architecture degree from a recognized university is eligible to get admitted into the graduate program at SUST.
- 1.4 Notification for the admission process will be published every year.
- 1.5 After admission every student will be assigned to a student advisor/supervisor from among the teachers of his/her discipline to guide him/her throughout the academic program.

### 2. Qualification

#### 2.1 Masters and M.Phil.

- 2.1.1 Any student with a Bachelors degree from SUST is eligible for admission to the Masters (General) Program.
- 2.1.2 Any student with a CGPA of 3.25 or more from SUST is eligible for admission to the Masters (Thesis), M.Sc. (Engineering) or M.Phil. Program.
- 2.1.3 Any student with a CGPA of 3.25 or more in Masters (Thesis), Masters (General) is eligible for admission to the M.Phil Program.
- 2.1.4 Four-year Graduates from other recognized universities and institutions with a CGPA of 3.25 or more can apply for admission to the Masters (Thesis), M.Sc. (Engineering) or M.Phil. Program. A candidate who passed under course system and seeks admission to M.Phil program has to have First class in Masters or 50% marks in Masters and at least 2nd division in all public examination.
- 2.1.5 Any student registered for Masters (General) or Masters (Thesis) may transfer to the M.Phil. program, offered by the relevant discipline, if he/she can maintain a CGPA of 3.25 or more during the first two semesters.
- 2.1.6 The GSC of a discipline will decide if a student from a related discipline will be allowed to apply to the graduate program of that discipline. In these cases if

necessary the GSC may ask the candidate to take extra under-graduate/graduate courses to ensure the basic foundation.

#### 2.2 Ph.D.

2.2.1 Candidates with Masters (Thesis), M.Phil. or M.Sc. (Engineering) Degrees are eligible for application for Ph.D. and will be selected after a written and/or viva voce examination and the proper evaluation of academic records by the GSC. A candidate who passed under course system and seeks admission to Ph.D. program has to have First class in Masters or 50% marks in Masters and at least 2nd division in all public examination.

2.2.2 A Masters (Thesis) an M.Phil. or an M.Sc. (Engineering) student may be transferred to the Ph.D. program after the completion of first two semesters with a CGPA 3.25 and the recommendation of his/her supervisor certifying satisfactory progress of research work and with the approval of the GSC and BAS.

2.2.3 The following candidates are eligible for direct admission to Ph.D. if they have a CGPA of 3.25 or more at Bachelors and Masters Level and 3.00 or equivalent in all public examinations. (i) University teachers with two years teaching experience and one publication in standard academic journals. (ii) Teachers of colleges with three years of teaching experience and one publication in a standard academic journal (iii) Researchers of recognized research organizations with three years of research experience and at least three publications in standard academic journals. (iv) Candidates with an M.Phil degree.

### 3. Admission

#### 3.1 Masters and M.Phil.

3.1.1 If a SUST graduate has the required qualifications he/she can be admitted to the Masters program (General, Thesis or Engineering) as per the recommendation of the GSC.

3.1.2 The candidates for Masters (Thesis and Engineering) and M.Phil. will be selected for admission after a written and/or viva voce examination conducted by the GSC. Full time teachers of SUST are not required to sit for the admission test. GSC will then recommend the candidates for admission to the academic council through the BAS. During the process of admission each candidate shall be assigned by the appropriate GSC and approved by BAS a supervisor from among the teachers of the relevant discipline/institute not below the rank of an associate professor or an assistant professor with a Ph.D. / M.Phil. / M.S.

#### 3.2 Ph.D.

3.2.1 A candidate for admission to the Ph.D. degree program will apply in the prescribed form to the head of the discipline or the director of institute along with the recommendation from possible supervisor(s). The supervisor must be of the rank of professor or associate professor.

3.2.2 After approval from the GSC, the application will be forwarded to the BAS for the approvals of the supervisor and co-supervisors (if any). Each candidate shall have not more than two co-supervisors; one co-supervisor may be from outside

SUST. After careful scrutiny of the research proposal BAS will send it to the Academic Council for final Approval.

3.2.3 If necessary a change of supervisor must also be approved by the BAS and the Academic Council.

#### 4. Registration

4.1 Every selected candidate will be registered with the University and enrolled as a full time or if allowed, part time student with payment of prescribed fees and dues before the commencement of each semester.

4.2 A candidate may be admitted or change his status into part time student with prior approval of the university and a written consent from the serving organization. A part time student may be assigned a minimum of 6 credit hours per semester.

4.3 A full time student must register for a minimum of 12 credits hours per semester. A full time student shall not be allowed to be employed as a part time employee in other organizations. However he/she may be employed as teaching/research assistant at the University. A Ph.D. candidate shall have to be a full time student for at least one year during his/her Ph.D. work.

4.4 The registration for the Ph.D. degree will remain valid for a period of four years, and can be renewed for a further period of two years.

#### 5. Academic Regulations

##### 5.1 Duration

5.1.1 The minimum duration for the Masters, M.Sc. (Engineering), M.Phil. and Ph.D. degrees will be as followed:

| Degree                  | Duration of Completion | Required Credits |
|-------------------------|------------------------|------------------|
| Masters (General)       | 2 Semesters            | Minimum 24       |
| Masters (Thesis)        | 3 Semesters            | 36               |
| M.Phil. / M.Sc. (Engg.) | 4 Semesters            | 48               |
| Ph.D.                   | 6 semesters            | 72               |

5.1.2 Minimum duration of M.Phil will be 4 Semesters for students who completed 3 years Bachelors and 1 year Masters degree. Minimum duration of M.Phil will be 2 semesters for students who completed 4 years Bachelors and 1 year Masters degree.

##### 5.2 Credit Requirement

5.2.1 For the graduate program a full time student has to register for at least 12 credits each semester. For course work 1 credit means one hour of contact hour per week and for research or project work 1 credit hour means at least three hours per week. A student will be allowed to take theoretical course and research work simultaneously. Once the course requirement is completed, for the research work a graduate student has to register for “independent study” as credit/no-credit basis to fulfill the 12 credits per semester requirement.

##### 5.3 Course Requirement

5.3.1 Syllabus committee for the graduate program will be comprised of the GSC members and two external members from other universities nominated by the Dean.

5.3.2 Every year the syllabus committee will design the graduate level courses for the respective disciplines and recommend the courses for approval of the Academic Council through the School and BAS. GSC can review the curriculum from time to time and recommend any change to the syllabus committee as may be considered necessary.

##### Masters and M.Phil.

5.3.3 Every Masters (general, thesis and engineering) and M.Phil. student has to complete at least 16 hours of theory course work during the first two semesters. GSC will propose the required courses to the students with consultation of respective supervisors. The course work for M.Phil Program may be reduced and relaxed according to the recommendation of GSC. In that case the duration may be reduced up to 1 year.

##### Ph.D.

5.3.4 The GSC may suggest courses, if felt necessary, for the Ph.D. students.

##### 5.4 Research Work Requirement

5.4.1 Research work for thesis shall be carried out under the supervision of the supervisor. Co-supervisors from within or outside the discipline / Institute may be appointed, if necessary. The topic of research proposal shall be approved by the BAS after the completion of the required course credits within six months/one year for M.Phil. / Ph.D. on the recommendation of the Head of the Discipline/Institute. A Ph.D. student must submit a progress report of his work to the supervisor(s) at the end of the every semester who will present it to BAS.

5.4.2 The Ph.D. student will give at least one public seminar talk conducted by GSC at the Discipline / Institute every year on a topic of his own field of research.

5.4.3 The research work must be carried out in this University or at a place approved by the supervisor in consultation with the GSC.

#### 6. Conduct of Examinations

##### 6.1 Course Examination

6.1.1 The examination committee will conduct the course examinations as per the examination ordinance of graduate program.

##### 6.2 Thesis Submission

6.2.1 The title of the thesis has to be approved by the BAS on the recommendation of the Head of the Discipline / Institute. For Masters/M.Phil. it has to be done at least three months and for Ph.D. it has to be done at least six months before submitting.

6.2.2 Every student shall submit to the supervisor required number of type written copies of his thesis in the approved format on or before a date to be fixed by the Head of the Discipline/ Institute in the consultation with the supervisor concerned.

6.2.3 The student shall declare that the research work was done by him/her and has not submitted elsewhere for other purpose (except for publication)

6.2.4 The thesis should demonstrate an evidence of satisfactory knowledge in the field of research undertaken by the student.

### **6.3 Masters Thesis Examination**

6.3.1 There is no thesis requirement for Masters (General). The project (if any) and the thesis for Masters (Thesis) will be evaluated as per the examination ordinance of graduate program.

### **6.4 M.Phil. / M.Sc. (Engineering) Thesis Examination**

#### **Thesis Evaluation**

6.4.1 The academic council will, on the basis of the suggestion of the GSC and recommendation of the BAS, appoint for every thesis an examination committee consisting of two examiners of whom at least one shall be from outside this University.

6.4.2 The examiners of thesis will either accept it or reject it for the degree and then individually and separately submit one copy of their reports in sealed covers to the controller of examination and another copy to the GSC Chairman. The majority decision will be considered as the final result.

6.4.3 If a thesis is adjudged inadequate for the award of the degree, the candidate will be allowed to resubmit his thesis within six months. If the candidate fails to resubmit or the thesis is adjudged inadequate again the examiners may recommend Masters (general) degree and the controller of examination will place such recommendation before the BAS for the approval of academic council.

#### **Oral Examination and Open Presentation**

6.4.4 The GSC in consultation with the supervisor shall suggest, to the Vice Chancellor through BAS, a committee of three members for oral examination consisting of: (i) Convener: Thesis supervisor (ii) A Professor in relevant field from outside the University (iii) One of the thesis examiners.

6.4.5 If any examiner is unable to accept the appointment or has to relinquish his appointment before/ during the examination, the Vice-Chancellor shall appoint another examiner in his place as per the recommendation of GSC,

6.4.6 After the oral examination the convener will send a consolidated report to the controller of examinations stating clearly whether the award of the degree is recommended, who will in turn place it to BAS for the approval of the Academic Council.

6.4.7 In case a candidate performs unsatisfactorily in oral examination even though the thesis is adjudged adequate the examiners may recommend to the Academic Council that the candidate may be permitted to appear at another oral examination within six months from the first oral examination. No candidate shall be allowed to appear at the oral examination of the same thesis for more than two times.

#### **Recommendation for Degree**

6.4.8 After completion for the viva-voce examination, the convener of the viva examination committee will send a consolidated report, stating clearly whether the

award of the degree is recommended, to the Controller who will in turn place it to BAS for the approval of the academic council.

### **6.5 Ph.D. Thesis Examination**

#### **Thesis Evaluation**

6.5.1 The academic council will, on the basis of the suggestion of the GSC and recommendation of the BAS, appoint for every thesis an examination committee consisting of three examiners of whom one shall be the supervisor and the other two from outside this University and at least one from a university from abroad

6.5.2 One of the three examiners will be appointed by the academic council as the convener of the examination committee.

6.5.3 The examiner of thesis will individually and separately submit one copy of their reports in sealed covers to the controller of examination and another copy to the convener. Every examiner will have to explicitly state whether the award of the Ph.D. degree is recommended or not. The recommendations of all the three examiners must be explicit, unambiguous and unanimous for the award of the degree.

6.5.4 If a thesis is adjudged inadequate for the award of the Ph.D. degree, the candidate will be allowed to resubmit his thesis after six months with proper modification. If the candidate fails to resubmit or the thesis is adjudged inadequate again the examiners may recommend the award of M.Phil. or M. S. degree and the controller of examination will place such recommendation before the BAS for the approval of academic council.

#### **Oral Examination and Open Presentation**

6.5.5 On receipt of the unanimous opinions of the examiners, the convener shall fix a date and a venue and suggest, to the Vice Chancellor through BAS, a committee of three members for oral examination consisting of the convener, supervisor/co-supervisor and a thesis examiner. At least one of them has to be from outside the university.

6.5.6 If any examiner is unable to accept the appointment or has to relinquish his appointment before/during the examination, the Vice-Chancellor shall appoint another examiner in his place as per the recommendation of GSC.

6.5.7 In case a candidate is unable to satisfy the viva voce Board even though the thesis is adjudged adequate the Board may recommend to the Academic Council that the candidate may be permitted to appear at another oral examination after a lapse of six months from the first oral examination. No candidate shall be allowed to appear at the oral examination of the same thesis for more than two times.

#### **Recommendation for Degree**

6.5.8 After completion of the viva voce examination, the convener will send a consolidated report to the controller of examinations stating clearly whether the award of the degree is recommended, who will in turn place it to BAS for the approval of the Academic Council.

## **7. Award of the Degree**

### **7.1 Masters**

7.1.1 Students will be awarded his/her degree as per the recommendation of GSC chairman after the completion of his required credits.

### **7.2 M.Phil. and Ph.D.**

7.2.1 The vice chancellor shall place the reports of the Oral Examination committee for consideration of the academic council which shall recommend to the Syndicate for the award of the degree.

7.2.2 A hard copy of the thesis accepted by the academic council incorporating any correction and changes suggested by the examination committee shall be preserved in the central library of the university and the corresponding electronic version shall be preserved in the archive.

## **8. Academic Fee**

8.1 To be decided by the Academic Council and the Syndicate.

## **Examination Ordinance for the Graduate Program**

University authorities will administer and publish the results of Masters, M.Phil. and Ph.D. degree examinations under the graduate program. The graduate program will follow the same academic calendar of the undergraduate program for course delivery, the final examination and publication of results. The graduate courses are comprised of theory and lab courses and where applicable, the thesis for the research works. The evaluation of thesis is conducted as per the Ordinance for the Graduate Program at SUST. The theory and lab courses are conducted by the examination committee.

### **1. Examination Committee**

1.1 The GSC of the Discipline/Institute will form the examination committee as per the rules of the University.

1.2 The examination committee will propose the examination schedule, prepare question papers, help the discipline conducting the examination, prepare results and will resolve the issues that may arise concerning the examination procedure.

### **2. Examination Dates and Routines**

2.1 The examination routines will be designed by the respective disciplines and Head of the disciplines will notify them and send copies to the other relevant disciplines and to the office of the Controller of the Examinations.

### **3. Theory Courses**

#### **3.1 Distribution of Marks**

A student will be continuously evaluated during the semester through tests, assignments, mid-semester examinations, viva etc. conducted by the course teachers, and it will contain 30% of total marks. The rest 70% marks will come from the final written examination at the end of that semester.

#### **3.2 Class Performance**

After the end of the classes, the course teachers will make three copies of mark-sheets showing the marks from class participation and assignment and mid semester examination. He/she will display one copy in the notice board, send one sealed copy to the chairman of the examination committee and another sealed copy to the controller of examination.

#### **3.3 Question Setting and Moderation**

3.3.1 The examination Committee will appoint two question setters for each course at least four weeks before the date of commencement of the examination and inform

the Controller of examination. The controller of examination will send the necessary papers to the question setters and the examiners. If a question setter or examiner declines the responsibility, he/she will return all the papers and the examination committee will suggest an alternative question setter or examiner.

3.3.2 The chairman of the examination committee will receive all the manuscript of question papers; if no manuscript is received within the specified time the committee will suggest an alternative question setter.

3.3.3 After receiving all the question papers the examination committee will moderate the question papers. Moderation will not be invalid if any member be absent during moderation. For the disciplines of the school of Applied Sciences and Technology the questions will be divided in two groups in the question paper so that two examiners can evaluate the answer script simultaneously. The examination committee will be responsible for the preparation of the necessary editing and printing of the question papers.

### 3.4 Final Examination

3.4.1 The controller of examination will be responsible to print the blank answer scripts, mark sheets and other relevant forms and will make necessary arrangements, so that these are available during the conduct of examination in the examination hall in due time .

### 3.5 Evaluation of Answer Script

3.5.1 The answer scripts from the disciplines of Applied Science and technology will be evaluated by two examiners simultaneously, of whom one should preferably the course teacher. The answer scripts from the disciplines of other school of studies will be evaluated by two examiners separately, of whom one should preferably the course teacher. The examiners will examine the scripts thoroughly, mark the scripts properly and grade legibly within the specified time. The examiners will send a sealed copy of mark-sheet to the controller of examination and one sealed copy to the chairman of the examination committee.

3.5.2 The examination committee will assign members from the committee to scrutinize the answer scripts and if any discrepancy is found the committee will make the necessary arrangements to fix the problem and inform the controller of examination.

3.5.3 If the difference between marks given by two examiners be 20% or more than 20% GSC will recommend a third examiner for approval by the V.C and marks given by 3rd examiner and the marks of the first or 2nd examiner which ever is nearest to this will be considered for the average marks .

## 4. Lab Courses

4.1 Every lab course will be assigned to at least two course instructors and they will grade the students through continuous evaluation.

4.2 For the projects, Masters (Thesis), Industrial assignments, monographs etc. the supervisor will give an overall assessment which will count as 30% of the total marks. Evaluation of the report by two external examiners, who is not involved in supervision/co-supervision will count as another 30% of the marks. The remaining 40% will come from the presentation and viva voce conducted by the examination committee. During viva-voce examination the supervisor or co-supervisor, if present, will not participate in marking.

## 5. Publication of Result

5.1 Three original tabulation sheets will be prepared by the tabulators and checked by all the members and signed by the tabulators and members of the examination committee. The tabulation sheets will contain the grade point average obtained in the specific semester. The tabulation sheets will be sent to the Controller of Examinations for his signature and approval by the Vice-Chancellor.

5.2 The Controller of Examination shall keep up to date record of all the grades obtained by the student in individual Academic Record Card. Grades shall be announced by the Controller of Examination at the end of each semester.

### Grade and grade points:

5.3 The letter grade and grade point will be awarded as follows:

| Numerical Grade      | Letter Grade | Grade Points |
|----------------------|--------------|--------------|
| 80% Or above         | A+           | 4.00         |
| 75% to less than 80% | A            | 3.75         |
| 70% to less than 75% | A-           | 3.50         |
| 65% to less than 70% | B+           | 3.25         |
| 60% to less than 65% | B            | 3.00         |
| 55% to less than 60% | B-           | 2.75         |
| 50% to less than 55% | C+           | 2.50         |
| 45% to less than 50% | C            | 2.25         |
| 40% to less than 45% | C-           | 2.00         |
| Less than 40%        | F            | 0.00         |

## 6. Security and Ethics

6.1 Everyone involved in the process of examination has to guard the security of the question papers, examination grades and the final results. An examinee can never try to influence the examiners and any such attempt has to be brought to the controller of examination.

6.2 A student may never be asked a question so that he is hurt because of his religious or ethnic background.

6.3 If some one involved in the examination process has the following relatives as examinee he/she should immediately inform in to the authority: (a) Husband/wife,

(b) Son/Daughter, (c) Brother/Sister, (d) Brother-in-Law/ Sister-in-Law (e) Son-in-Law/ Daughter-in-Law, (f) Nephew/ Niece, (g) Uncle/ Aunt, (h) First Cousins.

**Shahjalal University of Science and Technology, Sylhet**  
**Department of Statistics**  
**Syllabus for the Graduate Program**  
**Session: 2021-2022**

The syllabus for the Graduate Program in Statistics covers the requisite courses for the following degrees:

1. Masters (General) and Masters (Thesis)
2. Master of Philosophy (MPhil)
3. Doctor of Philosophy (PhD)

**1. Masters (General) and Masters (Thesis) Programs**

The courses for Masters (General) in Statistics are spread over two semesters – the first semester offers 14 credit courses and the second semester also offers 14 credit courses. The courses for Masters (Thesis) in Statistics are spread over three semesters with 14 credit courses in Semester – I, 14 credit courses in Semester – II and 8 credits research course in Semester – III. A student of Masters (General and Thesis) will have to take all the courses of Semester – I; any four theory courses of Semester – II including corresponding Labs and Viva-voce (Course No. STA500B). A student of Masters (Thesis) will have to complete Semester – III to carry out their research work. Selection of optional courses of Semester – II must be approved by the Graduate Studies Committee (GSC) and choice of Thesis Group students will be made by the GSC. A student must complete 28 credits for the Masters (General) degree and 36 credits for the Masters (Thesis) degree. Following are the courses:

**Semester – I**

| Course No. | Course Title                       | Hours/Week (Theory + Lab.) | Credits |
|------------|------------------------------------|----------------------------|---------|
| STA511     | Advanced Statistical Inference     | 2+0                        | 2.0     |
| STA511L    | Advanced Statistical Inference Lab | 0+2                        | 1.0     |
| STA512     | Advanced Multivariate Analysis     | 2+0                        | 2.0     |
| STA512L    | Advanced Multivariate Analysis Lab | 0+2                        | 1.0     |
| STA513     | Time Series Analysis               | 2+0                        | 2.0     |
| STA513L    | Time Series Analysis Lab           | 0+2                        | 1.0     |
| STA514     | Actuarial Statistics               | 2+0                        | 2.0     |
| STA514L    | Actuarial Statistics Lab           | 0+2                        | 1.0     |
| STA500A    | Presentation and Viva-voce         | 0+0                        | 2.0     |
|            | Total                              | 8+8                        | 14.0    |

**Semester – II(four theory courses with related lab from the following courses)**

| Course No. | Course Title                           | Hours/Week (Theory + Lab.) | Credits |
|------------|----------------------------------------|----------------------------|---------|
| STA521     | Econometrics                           | 2+0                        | 2.0     |
| STA521L    | Econometrics Lab                       | 0+2                        | 1.0     |
| STA522     | Advanced Biostatistics                 | 2+0                        | 2.0     |
| STA522L    | Advanced Biostatistics Lab             | 0+2                        | 1.0     |
| STA524     | Advanced Demography                    | 2+0                        | 2.0     |
| STA524L    | Advanced Demography Lab                | 0+2                        | 1.0     |
| STA525     | Advanced Generalized Linear Models     | 2+0                        | 2.0     |
| STA525L    | Advanced Generalized Linear Models Lab | 0+2                        | 1.0     |
| STA526     | Bioinformatics                         | 2+0                        | 2.0     |
| STA526L    | Bioinformatics Lab                     | 0+2                        | 1.0     |
| STA527     | Advanced Probability Theory            | 3+0                        | 3.0     |
| STA528     | Environmental Statistics               | 2+0                        | 2.0     |
| STA528L    | Environmental Statistics Lab           | 0+2                        | 1.0     |
| STA529     | Data Mining                            | 2+0                        | 2.0     |
| STA529L    | Data Mining Lab                        | 0+2                        | 1.0     |
| STA530     | Categorical Data Analysis              | 2+0                        | 2.0     |
| STA530L    | Categorical Data Analysis Lab          | 0+2                        | 1.0     |
| STA500B    | Presentation and Viva-voce             | 0+0                        | 2.0     |
|            | Total                                  |                            | 14      |

**Semester – III**

| Course No. | Course Title | Hours/Week (Theory + Lab.) | Credits |
|------------|--------------|----------------------------|---------|
| STA599     | Thesis       | ---                        | 8.0     |

## Detailed Syllabus

### STA511 Advanced Statistical Inference

*Theory: 2 Hours/Week 2.0 Credits*

Point estimation: classical approach, sufficiency and completeness, minimal sufficient statistic & ancillary statistics. Different methods of obtaining UMVUE. Rao-Blackwell theorem and Lehmann-Scheffe theorem. Asymptotic properties of maximum likelihood estimators. Fisher's information.

Bayesian approach: conjugate family of prior densities, vague prior knowledge, informative, non-informative, least informative priors. Loss function (symmetric and asymmetric loss function) and risk function, Bayes' risk, Bayes' estimation.

Location and scale invariance, Pitman estimator for location and scale parameters.

Robust estimation: robust L-M-R -estimations, estimation of the parameters using Huber  $\Psi$  function.

Interval estimation: central and non-central confidence intervals. General method of finding confidence intervals. Confidence interval for large samples. Joint intervals for several parameters. Bayesian interval.

Non-parametric estimation: kernel density estimation and regression function estimation, non-parametric maximum likelihood method.

Test of hypothesis: unbiasedness and consistency of tests. Principles of LR test and its applications. Asymptotic distribution of LR statistic. Sequential probability ratio test. Comparison with fixed sample size test. OC function. ASN function.

#### Books Recommended:

##### Main Text:

1. Casella G & Berger R L, Statistical Inference, 2<sup>nd</sup>Ed, Duxbury Thomson Learning, USA

##### Reference Books:

1. Barnett V, Comparative statistical inference, 3<sup>rd</sup>Ed, Wiley, NY
2. Beaumont G P, Intermediate Mathematical Statistics, 8<sup>th</sup>Ed, Chapman and Hall, London
3. Blackwell D A & Girshick M A, Theory of Games and Statistical Decision, Dover Publications, NY
4. Chernoff H & Moses L E, Elementary Decision Theory, Dover Publications, NY
5. Conover W J, Practical Nonparametric Statistics, 3<sup>rd</sup>Ed, Wiley, USA
6. Gibbons J D & Chakraborti, Nonparametric Statistical Inference, Chapman and Hall, NY
7. Hogg R V & Tanis E A, Probability and Statistical inference, 10<sup>th</sup> Ed, Prentice Hall, NY
8. Larson H J, Introduction to Probability Theory and Statistical Inference, 3<sup>rd</sup>Ed, Wiley NY
9. Lehman L E, Testing Statistical Hypothesis, 2<sup>nd</sup>Ed, Springer, NY
10. Lehman L E, Theory of Point Estimation, 2<sup>nd</sup>Ed, Springer, NY
11. Mood A M, *et al*, Introduction to The Theory of Statistics, 3<sup>rd</sup> Ed, McGraw Hill, NY
12. Rao C R, Linear Statistical Inference and Its Applications, 2<sup>nd</sup>Ed, Wiley, NY

13. Saxena H C & Surendran P U, Statistical Inference, 3<sup>rd</sup>Ed, S Chand & Company, India
14. Siegel S & Catellan N J, Nonparametric Statistics for the Behavioral Sciences, 2<sup>nd</sup>Ed, McGraw Hill, NY
15. Wald A, Sequential Analysis, Reprint Ed, Wiley, NY
16. Weiss L, Statistical Decision Theory, McGraw Hill, NY
17. Zacks S, Theory of Statistical Inference, 1<sup>st</sup>Ed, Wiley, NY

### STA511L Advanced Statistical Inference Lab

*Lab: 2 Hours/Week, 1.0 Credit*

Estimation of parameters (with estimated standard error) by different methods under classical and Bayesian approaches, construction of confidence interval and Bayesian interval, power function and power curves, SPRT, OC function, ASN.

### STA512 Advanced Multivariate Analysis

*Theory: 2Hours/Week, 2.0 Credits*

Tests for covariance and correlation patterns and multivariate normality. Simulation of multivariate normal variate.

Principal component analysis: Derivation of components, choosing principal components, properties, large sample inferences.

Factor analysis: explanatory and confirmatory factor analysis, factor models, estimation, loadings and communalities, factor rotation and factor scores.

Canonical correlation analysis: canonical variates and canonical variate analysis, canonical correlations, population canonical variables, sample canonical variables.

Discrimination and classification: separation and classification for two populations, classification functions, Fisher's discriminant function, Fisher's method for discrimination.

Multivariate Bayesian regression. Multivariate mixture model.

Similarities and dissimilarities: concept, uses in multivariate analysis.

Independent component analysis (ICA).

Multidimensional scaling: principal coordinate analysis, metric and non-metric multidimensional scaling, goodness of fit.

Cluster analysis: hierarchical and nonhierarchical clustering methods.

Correspondence analysis: basic concepts and definitions, reduction of dimensionality and its criteria, interpretation.

#### Books Recommended:

##### Main Text:

1. Johnson R A & Wichern D W, Applied Multivariate Statistical Analysis, 6<sup>th</sup>Ed, Prentice Hall, New Jersey

##### Reference Books:

1. Afifi A, *et al*, Practical Multivariate Analysis, 5<sup>th</sup>Ed, CRC Press, NY
2. Anderson T W, An Introduction to Multivariate Statistical Analysis, 3<sup>rd</sup>Ed, John Wiley, NY
3. Bhuiyan K C, Multivariate Analysis, Central Publications, Bangladesh

4. Chatfield C & Collins A J, Introduction to Multivariate Analysis, Springer, London
5. Krzanowski W J, Principles of Multivariate analysis: A User's Perspective, Revised Ed, Oxford University Press, USA
6. Manly B F J, Multivariate Statistical Methods – A Primer, 3<sup>rd</sup> Ed, Chapman and Hall, London
7. Mardia K V, *et al*, Multivariate Analysis, 7<sup>th</sup> Ed, Academic Press, NY
8. Morrison D F, Multivariate Statistical Methods, 4<sup>th</sup> Ed, Duxbury Press, USA
9. Neil H. Timm, Applied Multivariate Analysis, Springer
10. Rencher A C, Methods of Multivariate Analysis, 2<sup>nd</sup> Ed, John Wiley & Sons, USA

#### **STA512L Advanced Multivariate Analysis Lab**

*Lab: 2Hours/Week, 1.0 Credit*

Lab syllabus will be as instructed by the corresponding course teacher.

#### **STA513 Time Series Analysis**

*Theory: 2Hours/Week, 2.0 Credits*

Introduction: objectives of time series analysis, approaches to time series analysis, some descriptive techniques, examples.

Stationary time series models: autoregressive processes, moving average processes, the dual relationship between AR(p) and MA(q) processes, autoregressive moving average ARMA(p,q) processes.

Nonstationary time series models: non-stationarity in the mean, autoregressive integrated moving averages ARIMA models, non-stationarity in the variance and the autocovariance.

Forecasting: introduction, minimum mean square error forecasts, computation of forecasts, the ARIMA forecast as a weighted average of previous observations, updating forecasts, eventual forecast functions.

Model identification: steps for model identification, inverse autocorrelation function (IACF), extended sample autocorrelation function and other identification procedures.

Parameter estimation, diagnostic checking, and model selection: the method of moments, maximum likelihood method, non-linear estimation, ordinary least squares (OLS) estimation, diagnostic checking, model selection criteria.

Spectral theory of stationary processes: basic concept of Fourier series, the spectrum, the spectrum of some common processes, the spectrum of linear filters, aliasing. Estimation of the spectrum: periodogram analysis, the sample spectrum, the smoothed spectrum, ARMA spectral estimation.

State-space models and the Kalman filter: introduction, the relationship between state space and ARMA models, state space model fitting and canonical correlation analysis, the Kalman filter.

#### **Books Recommended:**

##### **Main Text:**

1. Brockwell P J & Davis R A, Introduction to Time Series and Forecasting, 2<sup>nd</sup> Ed, Springer, USA

##### **Reference Books:**

1. Basu A K, Introduction to Stochastic Process, Alpha Science International Ltd, UK
2. Box G E P, *et al*, Time Series Analysis: Forecasting and Control, 4<sup>th</sup> Ed, Wiley, NY
3. Chatfield C, The Analysis of Time Series: An Introduction, 6<sup>th</sup> Ed, Chapman and Hall, NY
4. Fuller W, Introduction to Statistical Time Series, 2<sup>nd</sup> Ed, John Wiley & Sons, NY
5. Makridakis S, Forecasting: Methods and Applications, 33<sup>rd</sup> Ed, John Wiley and Sons, NY
6. Wei W W S, Time Series Analysis: Univariate and Multivariate Methods, 2<sup>nd</sup> Ed, Addison-Wesley, UK

#### **STA513L Time Series Analysis Lab**

*Lab: 2Hours/Week, 1.0 Credit*

The detail syllabus will be prepared by the course teacher.

#### **STA514 Actuarial Statistics**

*Theory: 2 Hours/Week, 2.0 Credits*

Basic concepts: introductory concepts of actuarial science – nature and type of insurance, risk transfer concepts, claim management including handling, loss adjusting, aggregation, settlement, claims information system and reporting, reinsurance – definition, purpose, advantages and disadvantages. Models for individual claims and their sums, survival function, curate future lifetime, force of mortality.

Premiums: premiums, general premiums, natural premiums, office premiums, loading for expenses, with profit and without profit premiums, adequacy of premiums, relative consistency.

Life insurance: insurance payable at the moments of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurance recursions, commutation functions.

Actuarial models: survival models, estimating the lifetime distribution, Cox regression model, Markov models.

Probability models: multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premium and their numerical evaluations. Distribution of aggregate claims compounds Poisson distribution and its applications.

Applied actuarial statistical methods: decision theory, loss distribution, run off triangles and experience rating systems. Introduction to generalized linear models, risk models, ruin theory, credibility theory – estimation of credibility with Bayesian and non-Bayesian technique.

Loss model: models for loss severity, macro methods of run-off analysis, chain-ladder, least squares, separation, payment per claim incurred.

#### **Books Recommended:**

**Main Text:**

1. Atkison D B & Dallas J W, Life Insurance Products and Finance: Charting a Clear Course, Society of Actuaries
2. Jordan C W, Life Contingencies, 2<sup>nd</sup>Ed, Society of Actuaries, Illinois, USA

**Reference Books:**

1. Benjamin B & Pollard J H, Analysis of Mortality and Other Actuarial Statistics, 2<sup>nd</sup>Ed, Heinemann, London
2. Bowers N L, *et al*, Actuarial Mathematics, 2<sup>nd</sup>Ed, Society of Actuaries, Illinois, USA
3. Donald D W A, Compound Interest and Annuities, Heinemann, London
4. Federation of Insurance Institutes Study Courses: Mathematical Basis of Life Assurance, Federation of Insurance Institutes, Bombay
5. Gerber H U, Life Insurance Mathematics, 3<sup>rd</sup>Ed, Springer, Verlag, Germany
6. Klugman S A, *et al*, Loss Models: from Data to Decisions, 3<sup>rd</sup>Ed, Wiley, NY
7. Neill A, Life Contingencies, Heinemann
8. Panjer H H, Financial Economics: With Applications to Investments, Insurance and Pensions, The Actuarial Foundation
9. Spurgeon E T, Life Continuances, Cambridge University Press, UK

**STA514L Actuarial Statistics Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

The Syllabus of the course will be designed by the corresponding course teacher.

**STA521 Econometrics**

*Theory: 2 Hours/Week, 2.0 Credits*

Dynamic econometric model: lagged variables, autoregressive and distributed lag-models, Koyck approach to distributed lag-model.

Models of simultaneous relationships: simultaneous-equation models, structural and reduced form models, recursive model, identification problem, instrumental variable, ILS, 2SLS and 3SLS, FIML, and LIML methods of estimation.

Estimating the parameters of a set of error related economic relations: a seemingly unrelated regressions (SUR) model and its estimation, combining time-series and cross-sectional data.

Time series econometrics: stationarity, unit root tests, spurious regression, co-integration and error correction mechanism, vector autoregressive (VAR) models, estimation of VAR models, vector error correction (VEC) model, granger causality, ARIMA with intervention, ARIMA, SARIMA, ARCH, GARCH, EGARCH, IGARCH, TARCH, FIGARCH, PARCH, NARCH models.

Nonlinear least squares: nonlinear models, principles of nonlinear least squares estimation, properties of the non-linear least squares estimator.

**Books Recommended:****Main Text:**

1. Johnston J & DiNardo J, Econometric Methods, 4<sup>th</sup>Ed, McGrawHill, NY

**Reference Books:**

1. Koutsoyiannis A, Theory of Econometrics, 2<sup>nd</sup>Ed, Macmillan, London
2. Enders W, Applied Econometric Time Series, John Wiley & Sons, NY
3. Gregory C, Econometrics, McGrawHill, NY
4. Griffiths W E, *et al*, Learning and Practicing Econometrics, John Wiley & Sons, NY
5. Gujarati D N, Basic Econometrics, 4<sup>th</sup>Ed, McGrawHill, NY
6. Judge G G, *et al*, Introduction to the Theory and Practice of Econometrics, 2<sup>nd</sup>Ed, John Wiley & Sons, NY
7. Kmenta J, Elements of Econometrics, 2<sup>nd</sup>Ed, Macmillan, NY
8. Maddala G S, Introduction to Econometrics, 2<sup>nd</sup>Ed, PrenticeHall, Sydney
9. Pindyck R S, & Rubinfeld D L, Econometric Models and Economic Forecasts, 3<sup>rd</sup>Ed, McGrawHill, NY

**STA521L Econometrics Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

Fitting distributed lag models, detecting autocorrelation in distributed lag models, identification problem, fitting of simultaneous-equation models using ILS and 2SLS methods, tests of stationarity, estimating cointegration regression, fitting of ARIMA, ARIMA with intervention, SARIMA, ARCH, GARCH, EGARCH, IGARCH, FIGARCH, TARCH, PARCH, and NARCH models.

**STA522 Advanced Biostatistics**

*Theory: 2 Hours/Week, 2.0 Credits*

**Survival data:** Review of survival data including censoring and truncation.

**Review of nonparametric survival methods:** estimation of survival function, hazard function, reduced sample method, Kaplan-Meier or product limit method, actuarial method, estimation and standard error. Gehan test, Mantel-Haenszel test, Kruskal-Wallis test.

**Review of Parametric survival methods:** likelihood construction for censored and truncated data, inference procedures for exponential, gamma, Weibull, log-normal, log-logistic, and extreme value distributions for complete and censored data. Accelerated life tests: fitting accelerated failure time models and interpretation of results.

**Cox proportional hazards (PH) models:** proportional hazards models, application and limitations, conditional, marginal and partial likelihoods. Diagnostics procedure for the Cox PH model.

**Competing risks theory:** concepts, crude, net, partial crude probabilities, their interrelationships and estimation. Application of competing risks to current mortality data.

**Correlated survival data:** Basic concept of correlated survival data and frailty model

**Advanced models:** Estimation and test of hypotheses: Logistic and Loglinear models; Linear Mixed Models (LMM) and generalized linear mixed models (GLMM), and Generalized estimating equations (GEE).

**Clinical trials (Randomized Controlled Trial, RCT):** Concept of RCT, objectives, protocol of clinical trials, randomization, blinding, bias, error, sample size and power, parallel, crossover, sequential design and pragmatic trial. Drug trials: phase I, phase II, phase III and phase IV.

**Books Recommended:****Main Text:**

1. Kleinbaum, David G., Klein, Mitchel (2005), Survival Analysis: A Self-Learning Text, 3<sup>rd</sup> Edition, Springer-Verlang, NewYork.
2. Xian Liu (2012), Survival Analysis: Models and Applications, Wiley.
3. Lawless J F, Statistical Models and Methods for Lifetime Data, 2<sup>nd</sup> Ed, John Wiley & Sons, NY
4. Kleinbaum D G, *et al*, Epidemiologic Research: Principles and Quantitative Methods, Wiley & Sons, NY

**Reference Books:**

1. Altman D G, Practical Statistics for Medical Research, 1<sup>st</sup>Ed, Chapman and Hall/CRC, NY
2. Collett D, Modelling Survival Data in Medical Research, 2<sup>nd</sup>Ed, Chapman and Hall, Florida
3. Cox D R & Oakes D, Analysis of Survival Data, Reprint Ed, Chapman and Hall/CRC, NY
4. Dobson A J, An Introduction to Generalized Linear Models, 3<sup>rd</sup>Ed, Chapman and Hall, UK
5. Elandt-Jhonsen R C & Jhonsen N L, Survival Models and Data Analysis, Wiley, NY
6. Johnson R C E & Johnson N L, Survival Models and Data Analysis, Wiley, NY
7. Kalbfleisch J D & Prentice R L, The Statistical Analysis of Failure Time Data, 2<sup>nd</sup>Ed, Wiley & Sons, USA
8. Klein J P & Moeschberger M L, Survival Analysis: Techniques for Censored and Truncated Data, 2<sup>nd</sup>Ed, Springer
9. Lee E T, Statistical Method for Survival Data Analysis, 3<sup>rd</sup>Ed, Wiley & Sons, NY
10. McCullagh P & Nelder J A, Generalized Linear Models, 2<sup>nd</sup>Ed, Chapman and Hall/CRC, NY
11. Piantadosi S, Clinical trials: A Methodological Perspective, 2<sup>nd</sup>Ed, Wiley, NY

**STA522L Advanced Biostatistics Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

Nonparametric methods: reduced sample, actuarial and product-limit methods, estimation and tests.

Fitting of parametric models with complete and censored samples: exponential, gamma, Weibull distributions, graphical methods for survival distribution, estimation and tests, goodness of fit tests.

Competing risks: estimation of crude, net and partial crude probabilities, application of competing risks to current mortality data.

Application of i) Logistic and Poisson regression, ii) Proportional hazards models iii) Linear and generalized linear mixed model (LMM and GLMM) and iv) Generalized estimating equation (GEE).

**STA524 Advanced Demography**

*Theory: 2Hours/Week, 2.0 Credits*

Fertility: indirect method of estimation viz P/F ratio method, parity progression ratio, Gompertz model. Bongaart's proximate determinants of fertility and estimation of its indices. Fecundability: types and methods.

Morbidity and mortality: basic concepts of morbidity and its different measures. Mathematical models in mortality. Graduation of mortality curves.

Life table: UN model life tables, Coale-Demeny model life table. Brass-logit life table system. Sampling distribution of life table functions. Estimation of survival probability by the method of maximum likelihood.

Stable population theory: concept of stable, semi stable and stationary population. Stable age distribution. Interrelationships of demographic variables in stable population. Intrinsic rate of natural increase. Mean length of generation. Lotka's integral equation and solution for intrinsic rate of growth.

Aging: concept of aging, types of aging, population aging: concepts and socio-economic implication. Conventional measures, population momentum and aging.

Population projection: computational procedure for projecting population by component method. Development of Leslie projection matrix, forward and backward operation of population projection.

Some demographic models: nuptiality models –Coale's parameters of nuptiality, Coale-McNicol model.

Migration models – push-pull hypothesis, Ravenstein's seven laws of migration.

**Books Recommended:****Main Text:**

1. Biswas S, Stochastic Processes in Demography and Applications, Wiley Eastern, India
2. Preston S H, *et al*, Demography: Measuring Population Process, Blackwell Publishers, USA

**Reference Books:**

1. Barclay G W, Techniques of Population Analysis, John Wiley & Sons, NY
2. Bouge D J, Principles of Demography, John Wiley & Sons, NY
3. Coale A J & Demny P, Regional Model Life Tables and Stable Population, Princeton University Press, NY
4. Cox D R, Demography, Cambridge University Press, Cambridge
5. Journals of, Population Studies, Demography, Population and Development Review, Studies in family planning, ESCAP Population Journal, GENUS, Biosocial Science, Journal of Family Welfare
6. Keyfitz, N, Applied Mathematical Demography, John Wiley & Sons, NY
7. Keyfitz, N, Introduction to the Mathematics of Population, John Wiley & Sons, NY
8. Pollard J H, Mathematical Models for the Growth of Human Populations, Cambridge University Press, Cambridge
9. Rogers A, Introduction to Multi-Regional Mathematical Demography, Wiley Inter science, NY
10. Shryock H & Siegel J, The Method and Materials of Demography, Academic Press, NY

11. UN publications, Manual IV and Manual X, Population Bulletins, Population Debate
12. UNFPA, Population Research Methodology, Volumes: 1-10, Chicago

#### **STA524L Advanced Demography Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

Application of various indirect techniques for estimating fertility, mortality, marriage and migration. Problems and issues related to population growth. Problem of construction of abridged life table, un model life table. Projection of fertility and mortality, population projection, application of UN model life table in population projection. Application of various measures of aging.

#### **STA525 Advanced Generalized Linear Models**

*Theory: 2Hours/Week, 2.0 Credits*

Introduction to the concepts of modeling, model fitting: examples, some principles of statistical modeling (exploratory data analysis), model formulation, parameter estimation, residuals and model checking. Estimation and tests based on specific problems.

Sampling distribution for score statistics linear models (Bernoulli, binomial, Poisson, exponential, gamma, normal, etc)

Properties of distributions in the exponential family, expected value, variance, expected value and variance of score statistic, examples for various distributions.

Components of generalized linear models- random, systematic and link functions, Poisson regression.

Maximum likelihood estimation using chain rules, random component, mean and variance of the outcome variable, variance function, dispersion parameter, applications

Systematic component and link function: identity link, logit link, log link, parameter estimation score function and information matrix, estimation using the method of scoring, iteratively reweighted least squares

Inference procedures, deviance for logit, identity, log link functions, scaled deviance, sampling distributions, hypothesis testing.

Generalized Pearson chi-square statistic, residuals for glm, Pearson residual, Anscombe residuals

Logit link function, iteratively reweighted least squares, tests; nominal and ordinal logistic regression.

Goodness of fit tests, Hosmer-Lemeshow test, pseudo R square AIC and BIC.

Quasi likelihood, construction of quasi likelihood for correlated outcomes, parameter estimation, variance-covariance of estimators, estimation of variance function.

Quasi likelihood estimating equations, generalized estimating equations for repeated measures data, repeated measures models for normal data, repeated measures models for non-normal data, working correlation matrix, robust variance estimation or information sandwich estimator, hypothesis testing.

Comparison between likelihood and quasi likelihood methods, mixed effect models.

#### **Books Recommended:**

##### **Main Text:**

1. Dobson A J & BarnettAG, An Introduction to Generalized Linear Models 4<sup>th</sup>Edition, Chapmanand Hall, NY

##### **Reference Books:**

1. Collette, D, Modelling Binary Data, 2<sup>nd</sup>Ed, Chapman and Hall, UK
2. Hosmer D W & LemeshowS, Applied Logistic Regression, 2<sup>nd</sup>Ed, Willey, NY
3. McCullagh P & NelderJ A, Generalized Linear Models, 2<sup>nd</sup>Ed, Chapman and Hall, NY

#### **STA525L Advanced Generalized Linear Models Lab**

*Lab: 2Hours/Week, 1.0 Credit*

The Syllabus of the courses will be designed by the corresponding course teacher.

#### **STA526 Bioinformatics**

*Theory: 2 Hours/Week, 2.0 Credits*

Introduction to molecular biology of the cell: DNA, RNA, chromosome, gene and central dogma. Basic concepts of protein and metabolism.

Statistical methods for gene expression (transcriptomics) data analysis: introduction to microarrays and microarray data, image analysis, preprocessing: transformation and normalization. Identification of differential expressed genes in two or more groups using statistical tools: fold change, t-test, ANOVA. Uses of several *bioconductor* packages in r program, *e.g.* SAM, LIMMA *etc.* Multitest problems, remedial measures: the family-wise error rate (FWER) and the false discovery rate (FDR). Concepts of q-value. Introduction of RNA-seq data and its analytical procedures. Discuss statistical methods for protein and metabolomics data analysis Gene clustering and classification. Inferring genetic regulatory networks from microarray experiment with Bayesian networks. Modeling gene expression profile, clustering time course data using k-means, stem (short time series expression miner) algorithm and principal component analysis (PCA).

Integration of molecular datasets: basic concepts of integrating multi-block datasets of genomics data (gene, protein, and metabolism) and environmental data. Basic concepts of top-down and bottom-up systems biology.

#### **Books Recommended:**

##### **Main Text:**

1. Neale B M, *et al*, Statistical Genetics: Gene Mapping Through Linkage and Association,1<sup>st</sup>Ed, Taylor & Francis

##### **Reference Books:**

1. Alberts B, *et al*, Molecular Biology of the Cell, 5<sup>th</sup>Ed, Garland Science
2. Foulkes A S, Applied Statistical Genetics with R for Population Based Association Studies, Springer
3. <http://www.bioconductor.org/>
4. Husmeier D, *et al*, Probabilistic Modeling in Bioinformatics and Medical Informatics, 2<sup>nd</sup>Ed, Springer

5. Mount D W, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, NY
6. Rongling Wu&MaC, Statistical Genetics of Quantitative Traits: Linkage, Maps and QTL, Statistics for Biology and Health, 1<sup>st</sup>Ed, Springer
7. Warren J E&GrantG R, Statistical Methods in Bioinformatics: An Introduction, Statistics for Biology and Health, 2<sup>nd</sup>Ed, Springer

#### **STA526L Bioinformatics Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

The syllabus of the course will be designed by the corresponding course teacher, especially uses of several *bioconductor* packages in r program for identification significant genes, clustering genes profiles and integration purposes.

#### **STA527 Advanced Probability Theory**

*Theory: 3 Hours/Week, 3.0 Credits*

Queueing theory: introduction. Preliminaries: cost equations, steady-state probabilities. Exponential models: a single-server exponential queueing system, a single-server exponential system having finite capacity. Network of queues: open systems, closed systems, the system M/G/I. Variations on the M/G/I. The model G/M/I. Multiserver queues: erlang's loss system. The M/M/K queue, the G/M/K queue, the M/G/K queue.

Renewal processes: introduction, distribution of  $N(t)$ , limit theorems and their applications, renewal reward processes, semi-Markov processes, the inspection paradox, computing the renewal function.

Brownian motion: definition and basic properties, increments of Brownian motion, sample paths, geometric Brownian motion, integrated Brownian motion, Brownian motion with drift.

Martingales and stochastic calculus: filtration, martingales, sub-martingales, super-martingales, Doob's martingale inequalities, Doob's martingale convergence theorem. Ito stochastic integral: definition. Properties of the stochastic integral.

#### **Books Recommended:**

##### **Main Text:**

1. Karlin S & Taylor H M, A First Course in Stochastic Processes, 2<sup>nd</sup>Ed, Academic Press, NY

##### **Reference Books:**

1. Ash R B, Real analysis and Probability, Probability and Mathematical Statistics Series, Academic Press, NY
2. Baily N T J, The Element of Stochastic Processes, Wiley Series, NY
3. Bartlett M S, An Introduction to Stochastic Processes, Wiley Series, NY
4. Bhat U N, Elements of Applied Stochastic Processes, 3<sup>rd</sup>Ed, John Wiley & Sons, NY
5. Billingsley P, Probability and Measure, 3<sup>rd</sup>Ed, Wiley Series, NY
6. Brzezniak Z &ZastawniakT, Basic Stochastic Processes, Springer, Verlag
7. Chung K L, Elementary Probability Theory with Stochastic Processes, 3<sup>rd</sup>Ed, Springer, Verlag

8. Cox D R & MillerW, The Theory of Stochastic Processes, Chapman and Hall, UK
9. Evans L C, An Introduction to Stochastic Differential Equations, Version 1.2, Department of Mathematics, UC Berkley
10. Grimmett G R &StirzakerD R, Probability and Random Processes, 3<sup>rd</sup>Ed, Oxford Science Publications
11. Karatzas I&ShreveS E, Brownian Motion and Stochastic Calculus, Springer, Verlag
12. Ross S M, Introduction to Probability Models, 9<sup>th</sup>Ed, Academic Press, NY
13. Ross S, Stochastic Processes, 2<sup>nd</sup>Ed, John Wiley & Sons, Canada
14. Shreve S, Stochastic Calculus and Finance, Lecture Notes
15. Taylor H M &KarlinS, An Introduction to Stochastic Modeling, 3<sup>rd</sup>Ed, Academic Press, NY

#### **STA528 Environmental Statistics**

*Theory: 2 Hours/Week, 2.0 Credits*

Environmental pollution: pollution and its importance, reasons of pollution. Pollutant sources, detailed study on air and water pollution; global climate change.

Stochastic processes in the environment: applications of Bernoulli, Poisson and normal processes to environmental problems.

Environmental sampling: network sampling, composite sampling, ranked-set sampling.

Detectability of sampling: basic concept of detectability, constant detectability over a region, estimating detectability, the effect of estimated detectability, detectability with simple random sampling.

Diffusion and dispersion of pollutants: wedge machine, particle frame machine and plume model.

Dilution of pollutants: deterministic dilution, stochastic dilution, and the theory of successive random dilution (SRD), applications of SRD to environmental phenomena: air quality, indoor air quality, water quality, concentrations of pollutants in soils, plants and animals and concentrations in foods and human tissue.

Statistical theory of rollback (STR): predicting concentrations after source control, correlation, previous rollback concepts, environmental transport models in air and water.

#### **Books Recommended:**

##### **Main Text:**

1. Barnett V, Environmental Statistics: Methods and Applications, John Wiley & Sons, NY

##### **Reference Books:**

1. Articles from Different Journals and Periodicals
2. Barnett V & Turkman K F, Statistics for the Environment, Volume 1, John Wiley & Sons, Chichester
3. Bryan F J, Statistics for Environmental Science and Management, 2<sup>nd</sup>Ed, Chapman and Hall/CRC Press
4. Harris J M & RoachB, Environmental and Natural Resource Economics: A Contemporary Approach, Houghton Mifflin Company

- Hill M K, Understanding Environmental Pollutions, 3<sup>rd</sup>Ed, Cambridge University Press, UK
- Millard S P & Neerchal N K, Environmental Statistics Using S-PLUS, Chapman and Hall/CRC Press
- Robert H, Spatial Data Analysis in the Social and Environmental Sciences, Cambridge University Press, UK
- Thomson S, Sampling, 3<sup>rd</sup>Ed, John Wiley & Sons, NY
- Townend J, Practical Statistics for Environmental and Biological Scientists, John Wiley and Sons, NY
- Wayne R O, Environmental Statistics and Data Analysis, Lewis Publishers, NY

### **STA528L Environmental Statistics Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

The Syllabus of the course will be designed by the corresponding course teacher.

### **STA529 Data Mining**

*Theory: 2 Hours/Week, 2.0 credits*

Overview: meaning of data mining and knowledge discovery basic, data mining tasks: classification, regression, time series analysis, prediction, clustering, summarization, association, rules, sequence discovery. Development of data mining, data mining issue and mining metrics, social implications of data mining.

Related concepts of data mining: fuzzy sets: introduction, classical sets, set operation, Boolean logic, basic concepts of fuzzy sets, other representations of fuzzy sets, determination of membership functions, fuzzy sets properties, operations on fuzzy sets, logic operations, algebraic operations on fuzzy sets.

Fuzzy relations: classical relations, classical reasoning, fundamentals of fuzzy relations, operations on binary fuzzy relations, types of fuzzy relations, fuzzy reasoning concluding remarks, bibliography, web resources. Data base/OLTP systems, logic, information retrieval, decision support systems, dimensional modeling, multidimensional schemas, indexing, data warehousing, OLAP, web search engines, statistics, machine learning, pattern matching.

Data mining techniques: statistical perspective on data mining: point estimation, models based on summarization, Bayes' theorem, hypothesis testing, regression and correlation. Similarity measures; decision tree; genetic algorithms.

Neural networks: background, learning, the basic neuron model, the perception, the multiplayer perception recurrent network, Hopfield, networks, Boltzmann machine network, Kohonen self-organizing networks, background, description, determining the winning neuron, learning algorithm.

Classification: issues in classification, statistical-based algorithms, regression, Bayesian classification, distance-based algorithms, K-Nearest neighbors, decision tree-based algorithms, ID3, C4.5 and C5.0, cart, neural network-based algorithms, propagation, NN supervised learning, radial basis function networks, perceptions, rule-based algorithms, generating rules from a DT, generating rules from a neural net.

Clustering: similarity and distance measures, outliers, hierarchical algorithms, agglomerative algorithms, divisive clustering, partitional algorithms, minimum spanning tree, squared error clustering algorithm, k-means clustering, nearest

neighbor algorithm, pam algorithm, bond energy algorithm, clustering with genetic algorithms, clustering with neural networks, clustering large databases, clustering with categorical attributes.

Association rules: meaning of association large itemsets, basic algorithms, *apriori* algorithm, sampling algorithm, partitioning, parallel and distributed algorithms, data parallelism, task parallelism, advanced association rule techniques, quantitative association rules, correlation rules, measuring the quality of rules.

Web mining: web content mining, crawlers, harvest system, virtual web view, personalization, web structure mining, page rank, clever, web usage mining, preprocessing, data structures, pattern discovery, pattern analysis.

### **Books Recommended:**

- Larose D T, Data Mining: Methods and Models, John Wiley & Sons, NY
- Schalkoff R, Pattern Recognition: Statistical, Structural and Neural Approaches, John Wiley & Sons, NY
- Dunham M H, Data Mining, Pearson Education Asia
- Ibrahim A M, Fuzzy Logic for Embedded Systems Applications, Elsevier Science, USA

### **STA529L Data Mining Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

Determination of partition of set of data by sum of squares of errors, clustering criteria, hierarchical clustering by nearest neighbor, further neighbor, k-means method or algorithm, determination of minimum distance decision boundary, performing K-NN classification using the Euclidean and statistical matrix. Application of different rules of data mining, classification by regression tree, decision tree, Bayesian approach and neural network.

### **STA530 Categorical Data Analysis**

*Theory: 2 Hours/Week, 2.0 credits*

Introduction: distributions and inference for categorical data. Describing contingency tables. Inference for contingency tables. Fixed margin. Introduction to generalized linear models. Logistic regression. Building and applying logistic regression models. Logit models for multinomial responses. Loglinear models for contingency tables. Building and extending loglinearlogit models. Models for matched pairs. Analyzing repeated categorical response data. Random effects: generalized linear mixed models for categorical responses. Other mixture models for categorical data. Asymptotic theory for parametric models. Alternative estimation theory for parametric models. Selection of a model. Fixed and random zeros.

### **Main Text:**

- Agresti A, Categorical Data Analysis, 3<sup>rd</sup> Edition, Wiley, NY
- Everitt B. S., (2019), The Analysis of Contingency Tables, 2<sup>nd</sup> Edition, Chapman & Hall, CRC Press

### **Reference Books:**

- Bilder C R & Loughin T M (2014), Analysis of Categorical Data with R, Chapman & Hall/ CRC

2. Fienberg S E (1989), The Analysis of Cross-Classified Categorical Data, 2<sup>nd</sup> Ed, The MIT Press, London
3. Lawal B (2003), Categorical Data Analysis with SAS® and SPSS Applications, Lawrence Erlbaum Associates, NJ
4. Stokes M E & Davis C S (2012), Categorical Data Analysis Using SAS, 3<sup>rd</sup> Ed, SAS Press

### **STA530L Categorical Data Analysis Lab**

*Lab: 2 Hours/Week, 1.0 Credit*

The Syllabus of the course will be designed by the corresponding course teacher.

### **STA599 Thesis**

*Research work: 8.0credits*

Each thesis students will be assigned a supervisor and/or co-supervisor. The topic will be determined through consultation with the supervisor.

### **2. Master of Philosophy (MPhil) Program**

A student of Masters of Philosophy (MPhil) program may have to take necessary theory courses during the first two semesters of the program as per graduate ordinance clause 5.3.3. The selection of the courses will be made by the GSC in consonance with the research field of the fellow from the existing courses of Masters level. The GSC may waive all or some of the theory courses for the fellows if the courses have already been taken by the fellows.

### **3. Doctor of Philosophy (PhD) Program**

For the PhD program, the GSC may suggest the theory courses for the fellows if necessary.