BANARAS HINDU UNIVERSITY



(Established by Parliament by Notification No. 225 of 1916)

Ordinance for Special Postgraduate Course

On

Master of Science (M.Sc.) STATISTICS AND COMPUTING

w.e.f 2017-18

OFFERRED BY:

DST-Centre for Interdisciplinary Mathematical Sciences (CIMS)

Faculty of Science

Banaras Hindu University

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1. **Admission**

Admission in the course is made according to the merit in the Entrance test (70%) & interview (30%), subject to fulfilling of eligibility requirements mention below. However, if the number of applicants for a particular course is less than twice the minimum number of seats, no entrance test shall be conducted. In that case, admission to the course would be made on the basis of merit in the qualifying examinations and/or written/subjective test conducted by the Departments/Faculty subject to fulfilling of eligibility requirements mention below. In case the number of applicants is less than minimum number of seats in the course, the course would not run in that session.

|  |  |
| --- | --- |
| * 1. Minimum eligibility criterion, number of seats, fee, and duration of the course | |
| NOTE: | Relaxation in minimum eligibility for Scheduled Castes (SC) / Scheduled Tribes (ST) / Other Backward Classes (OBC)/OBC-Minorities/Physically Challenged (PC) candidates given as other ‘special courses’ of faculty of science. |
| Course Name: | Master of Science (M.Sc.) STATISTICS AND COMPUTING |
| Duration: | 4 Semester (2 year) |
| Minimum Eligibility Criterion\* | Any science graduate under 10+2+3 pattern securing minimum 50% marks in aggregate and having statistics as one of the subject at the UG level. |
| Number of Seat | Minimum: 10 Maximum: 30 |
| Fee | Rs. 20,000/- per semester |

\*NOTE 1: For all courses the applicants having a degree equivalent to the degree of qualifying examination recognized by the Banaras Hindu University are also eligible (if they satisfy all other requirements for admission in the concerned course).

\*NOTE 2: Relaxation in minimum eligibility for scheduled castes (SC), scheduled tribes (ST), other backward classes (OBS), other backward classes-minorities (OBC-minorities) and physically challenged (PC) candidates are same as other ‘special courses’ of faculty of science BHU.

\*NOTE 3: Rules regarding minimum eligibility requirement other than given above is same as other ‘special courses’ of faculty of science BHU.

* 1. Reservation / Supernumerary seat / Employee: Reservation for SC/ ST/ OBC/ OBC-minorities/ PC / supernumerary seats and employee word is same as other ‘special courses’ of faculty of science BHU.
  2. Scheme of Entrance Examination: The examination shall comprise of two paper of two hours duration consisting of objective type questions based on Mathematics or Statistics or computer science/IT.
  3. **Syllabus for the Entrance Examination:** The question papers shall be based on B.Sc. courses up to 2nd year and Engineering courses up to VIth semester generally taught at graduation level. The detail entrance syllabus and guideline will be given in admission broacher.
  4. **Merit List for Admission** 
     1. Candidates shall be selected in order of merit on the basis of the aggregate marks secured in the entrance and interview provided that a candidate has obtained not less that 35% marks in the aggregate marks of entrance and interview. In case SC/ST candidates it shall be 30% in aggregate marks of entrance and interview.
     2. In the case of equal marks the *inter-se* ranking of the candidates shall be decided in the following order:

1. The aggregate marks obtained by the candidates at the qualifying examination recognized for the purpose of appearing in the entrance examination.
2. If the marks at the above examination are equal the aggregate per cent of marks obtained at Intermediate or equivalent examination.
3. If the marks at the above [1.6.2. (i) – (ii)] examination happen to be the same, the date of birth would be the basis, i.e. the candidate senior in the age would rank higher.
   * 1. In all matters relating to M.Sc. STATISTICS AND COMPUTING admission decision of a Committee comprising the admission committee of the centre shall be final.
     2. No scrutiny / revaluation of the answer books of the Entrance test shall be allowed.
     3. The candidates selected for admission will be informed individually by registered post / e-mail / telephone.
     4. A candidate/ candidates selected for admission may be referred to a Medical Board for Medical Examination for fitness by the Admission Committee.
4. **Cancellation of Admission**

The admission of a M.Sc. student is liable to be cancelled on the occurrence of any of the following:

1. If he /she fails to attend classes, and absents regularly for 15 days or more without permission.
2. If he /she fails to register in any course / project credits in any of the semester(s) unless he/she has dropped that semester(s).
3. If his/ her attendance is less than 15% in any semester.
4. On an act of indiscipline as per university rules
5. **Residential Requirement**

Minimum residential requirement shall be four (4) semesters, extendable to a maximum of eight (8) semesters in total.

1. **Credit and course requirement**
   1. In order to qualify for the M.Sc. STATISTICS AND COMPUTING degree a student shall offer not less than 80 credits. The distribution of the credits is given below:
      1. Compulsory theory and practical course not less than 62 credits shall be taken by all the students as prescribed.
      2. Minor 4 credits (2 credits in 2nd semester and 2 credits in 3rd semester) from other departments of faculty.
      3. Elective courses not less than 6 credits shall be taken by all the students as prescribed.
      4. Project credits : 8
   2. A student cannot offer the same course again in any degree programme unless failed.

**Part II: EVALUATION OF THE COURSE WORK AND EXAMINATION SYSTEM**

1. **Examination:** 
   1. There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper (Core Courses, Elective papers) except Paper No. MSMS - 307: Project Work in Semester – III and MSMS - 407: Project Work in Semester – IV.
   2. Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions.
   3. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions.
   4. Each Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce.
   5. All the practical papers shall be of FOUR HOURS duration.
   6. Mentor for the Project will be assigned at the beginning of the semester and it will be spread over the whole semester. The topic and problem will decided by the mentor. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, simulation / experiment result, personal opinion and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the mentor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce.
   7. Students should earn credit for the two MINOR ELECTIVE THEORY papers (MSMS-204M of semesters – II and MSMS-304M of semester III) from other departments of the faculty.

**Note:** The titles, contents of theory papers as well as practical papers and distribution of credits to papers are given in course structure and syllabi section.

1. **Allotment of project mentor / supervisor** 
   1. The supervisor of the project, appointed by the academic committee / board of study of the department concerned in the beginning of 3rd semester, shall be the advisor - chairman. The Chairman will nominate the other two members of the project advisory committee from the related discipline in consultation with Head of Department.
   2. Functions of the Advisory Committee

The advisory committee shall guide a student in the selection of suitable research / development problem for project and in all other matters relating to his/ her project related academic activities.

* 1. The details of the programme of work prepared by the project Advisory Committee shall be submitted to the Head of the Department end of each Semester.

1. **Attendance**
   1. A student is required to have full, i.e., 100%, attendance and condonation upto 30% can be considered for specific cogent reasons. Out of this 30%, only 10% condonation shall be permitted without taking any application from the student. Rest 20% condonation may be given by the Dean, Faculty of Science/Principal. Further, a student shall be deemed to have minimum percentage of attendance only if, apart from above, he/she has attended at least 50% of the classes in each course also. The cogent reasons for condonation are given below:
   2. Participation in NCC/NSC/NSS Camps duly supported by certificate.
   3. Participation in University or College Team Games or Inter-State or Inter University tournaments, duly supported by certificate from the Secretaryof the University Sports Board or President of the College Athletic Association concerned.
   4. Participation in Educational Excursion, which forms a part of teaching in any subject conducted on working days duly certified by the Dean, Faculty of Science.
   5. University Deputation for Youth Festival duly certified by the Dean, Faculty of Science.
   6. Prolonged illness duly certified by the Medical Officer or the Superintendent, S.S. Hospital, Banaras Hindu University or any other Registered Medical Practitioner, provided such certificate is submitted to the Coordinator of the center.
   7. **No relaxation beyond 30% shall be considered in any case.**
   8. The attendance of a newly admitted candidate shall be counted from the date of his/her admission, or date of starting of classes whichever is later while in the case of promoted candidates, attendance shall be counted from the date on which respective class begins. However, in case of promotion after declaration of results of supplementary examination (if any), the attendance will be counted from the date of admission in the respective case.
   9. There shall be an Attendance Monitoring Committee in the centre under the Chairmanship of the coordinator of the centre.
2. **The Performance Indicator** 
   1. **Calculation of performance indicator**: The performance indicator of a candidate in a semester or up to a semester shall be measured by SGPA and CGPA, details of which are given below:

SGPA : Semester Grade Point Average.

CGPA : Cumulative Grade Point Average.



Where = Number of credits assigned for the ith course of a semester for which SGPA is to be calculated.

*Pi* = Grade point earned in the ίth course. *i* = 1, ------- *n*, represent the number of courses in which a student is registered in the concerned semester.

**Note:** For calculation of SGPA and CGPA, credits of compulsory and optional courses shall not be taken into account.



where, *Cj*= Number of credits assigned for the *jth* course, up to the semester for which CGPA is to be calculated.

*Pj* = Grade point earned in *jth* course. *j* = 1, ------- *m*; represent the number of courses in which a student was registered up to the semester for which CGPA is to be calculated.

* 1. **Grading System:** The grading system, as detailed hereunder in **Table 1** shall be applicable for each course.

**Table - 1**

**Award of Grades Based on Absolute Marks**

**(If the number of candidates in the paper is less than 20)**

|  |  |  |
| --- | --- | --- |
| **Marks Range (Out of 100)** | **Grade** | **Grade Point** |
| 90 -100 | S | 10 |
| 80 - 89 | A | 9 |
| 70 - 79 | B | 8 |
| 60 - 69 | C | 7 |
| 50 - 59 | D | 6 |
| 40 - 49 | E | 5 |
| Passed with Grace | P | 4 |
| 00 - 39 | F | 0 |
| Non-appearance in examination (Incomplete) | I | 0 |
| Incomplete Project | X | 0 |

**Explanation:**

Latter grades **S, A, B, C, D, E and P** in a course mean that the candidate has passed that course.

**The F Grade:** denotes poor performance, i.e., failing in the course. A student has to appear at subsequent examination(s), if provided under the ordinances in all courses in which he/she obtains "F" grade, until a passing grade is obtained.

**The I Grade:** The "I" Grade is awarded, when a student does not appear in the examination of course/courses. This shall be treated as "F" Grade.

**The X Grade:** An "X" Grade is awarded to a student if he / she does not complete Project/Dissertation/Training. This will be converted to a regular grade on the completion of the Project/Dissertation/Training Work and its evaluation. The "X" Grade shall be treated as "F" Grade.

* 1. **Grace Rule:** Tabulators shall award grace marks as per the following guidelines:
  2. A student who fails in not more than 3 theory courses by total marks of not morethan ½ the number of total theory courses of the semester (any) fraction is rounded off to the next higher number), shall be awarded grade "P" (in place of grade "F") of Grade Point 4 in the concerned courses.
  3. Grace mark will not be awarded for making up shortfall in minimum SGPA/CGPA or improving the grade.

**CONFIDENTIAL CLAUSE**

1. **Evaluation of sessionals / tutorials / class tests / seminars in class / group discussions in each theory paper (30 marks)**
2. At the discretion of the concerned Head/Coordinator, a student who could not appear in the internal test(s) already conducted on account of some cogent reasons, such as late admission, illness etc., may be allowed to appear in the internal assignment/ test held for such a student.
3. The class tests shall be conducted by the teacher (or group of teachers) teaching the course and the marks shall be displayed on the Notice Board.
4. Centre-coordinators shall ensure that all internal assessment marks of sessionals are sent to Controller of Examination prior to the commencement of End Semester Examination.
5. Seasonal marks of a course shall be carried over for failed students in the course.
6. **End Semester Examination and Evaluation (for 70 marks):**
7. The question papers shall be set and the answer-scripts shall be evaluated by the teachers of the concerned courses. If there are more than one teacher teachingthe course, the question paper shall ordinarily be set and evaluated by a teacher of the group, appointed by the Board of Examiners.
8. The End Semester examination answer-scripts shall be shown to the students after evaluation by the concerned teachers within 7 days of the last examination for the semester. Thereafter, within a week, all the answer books along with the statement of marks shall be sent by the examiner to the Office of the Controller of Examinations for declaration of the results.
9. In case of any objection by a student in the evaluation, the same shall be looked after by a panel of two senior faculty members, to be nominated by the Dean, whose decision shall be final.
10. In cases of practical examination and project/ dissertation evaluation, external examiner may be appointed if and where considered necessary.
11. **There shall be no provision for re-evaluation**.
12. **Admit Card (for End Semester Examinations)**: A candidate may not be admitted into examination room unless he/she produce his/her admit card to the officer conducting the examination or satisfies such officer that it will be subsequently produced. The Centre-coordinator / Controller of Examinations may, if satisfied that an examinee’s admit card has been lost or destroyed, grant duplicate admit card on payment of fee decided by university.
13. **PROMOTION RULES AND SUPPLEMENTARY EXAMINATION**

There shall be no supplementary examination for Ist & IInd semesters. However, there shall be supplementary examination for IIIrd and IVth semesters after declaration of the results of IVth Semester. Students failing in courses of IIIrd and IVth semesters may appear in supplementary examination(s) or subsequent main examination(s).

* 1. **First Semester Course & Examination*:***

The candidates who have taken admission in the First Semester of a 2-year programme in a session can be put in the following two categories on the basis of their attendance in the Semester:

**Category I:**

1. Those who have put in the required minimum percentage of attendance for appearing in the First Semester Examination and filled up the examination form in time for appearing at the First Semester Examination.
2. Those who did not put in the required minimum percentage of attendance for appearing at the First Semester Examination or did not fill up examination form in time for appearing at the First Semester Examination.

**Candidates under Category I-(i)** are eligible for appearing at the examination of First Semester, while **candidates under Category. I-(ii)** are not allowed to appear at the examination of the Semester. However, category **I-(ii)** candidates are allowed to reappear at the Post-graduate Entrance Test (PET) of subsequent year(s) for seeking admission afresh. This implies that **no readmission is** **permissible to those who do not put in the required percentage of** **attendance for taking the examination or did not submit the examination** **form in time**.

**Category II:**

After appearing at the Examination of First Semester the candidates can be put in the following categories in the context of declaration of the results of the First Semester Examination:

1. **Passed,** i.e., those who have passed in examinations of all courses of the Semester.
2. **Promoted,** i.e., those who have not passed in examinations of all the courses of the semester.
3. **Minimum passing grade** – Grade ‘E’ for each course. However, candidates with grade ‘P’ in a course shall also be considered as passed in that course.
4. **Promotion to Second Semester**: All students who have put in the minimum percentage of attendance in Semester I and filled up the examination form in time shall be promoted to the Semester II.
   1. **Second Semester Course & Examination:**

As in the First Semester, in all subsequent Semesters, all the candidates who have put in the minimum percentage of attendance for appearing at the Examination and have filled in the examination form in time for appearing at the End Semester Examination shall be allowed to appear at the respective examinations. However, students who have not put in the minimum percentage of attendance or did not fill up the Examination form in time in Semester shall be allowed to take re-admission in that Semester **(except in the First Semester where** **re-admission is not permitted)**.

* 1. **Declaration of results after IInd Semester (based on the results of Ist and IInd** **Semester Examinations):**

After declaration of results of the First & Second Semesters, a candidate can be put in the following categories:

1. **Passed:** A candidate who has passed in examinations of all the courses of the First & Second Semesters.
2. **Promoted:** A student, who has not passed in all the courses of either Ist or IInd semester or both, shall be promoted to the IIIrd semester if he/she has obtained at least 4.0 CGPA. All such students shall have the option to clear the courses, in which they had failed, in the subsequent available examination(s) of the concerned semester as ex-students.
3. **Failed:** A candidate who has failed in one or more courses or failed to appear at any of the examinations of Ist and IInd Semesters taken together, and has obtained less than 4.0 CGPA shall be treated as failed.

***Note:*** *There shall be no supplementary examination for the courses of Ist and IInd semesters.*

* 1. **Promotion to the IIIrd Semester:**

1. A candidate who comes under the category **‘Passed or Promoted’** is eligible to be promoted to the third Semester, if otherwise eligible.
2. Failed candidates shall not be promoted to the IIIrd Semester. However, they shall be promoted to the third semester when they become eligible to come under the category of either ‘Passed’ or ‘Promoted’ as explained above after passing the failed courses in the subsequent available examination(s) as exstudents.
   1. **Promotion to the IVth Semester:**

All students who have put in the minimum percentage of attendance in IIIrd Semester and filled in the examination form in time shall be promoted to the IVth Semester.

* 1. **Declaration of Results after Fourth Semester (Based on the results of the Ist, IInd,**

**IIIrd and IVth Semester Examination):**

After declaration of results of IIIrd and IVth Semesters, a candidate can be put in the following two categories:

1. **Passed:** A candidate who has passed in all the courses of I, II, III and IV Semesters and obtained at least CGPA of 5.0.
2. **Failed:** All those students who have not “Passed” shall be categorized as “Failed”. Such failed students may clear their failed courses in subsequent examinations as exstudents. There shall be a provision of supplementary examinations for III and IV Semesters after declaration of results of IV Semester. Students failing in courses of III and IV Semesters may appear in the supplementary examination or subsequent main examination(s).

***A student who has failed in a course shall get two more chances to clear this course subject to the maximum duration for passing the course. Further, each candidate shall have to clear all the courses within the maximum period of 4 years from the date of his/her latest admission.***

* 1. **Maximum duration for passing the course:**

The maximum duration for passing the 2-years PG programme shall be 4 years, which shall be counted from the year of latest admission in the Ist semester of the PG programme. No student shall be allowed to take further admission in the programme after the expiry of four years.

* 1. **Deposition of Fees:**

All students eligible for promotion to third semester shall deposit the requisite fee for semesters 3 & 4 (Second academic year) within the time prescribed by the University.

1. **Declaration of Division**

A candidate who has passed in all the papers/ courses of Ist, IInd, IIIrd and IVth Semesters shall be declared as ‘Passed’. Such passed candidates may be awarded with the division according to the following criteria:

1. First Division with distinction : CGPA 8.5 and above
2. First Division : CGPA 6.5 and above, but below 8.5
3. Second Division : CGPA 5.0 and above, but below 6.5

**Note:** The SGPA & CGPA shall be computed up to 2 decimals places (truncated at the 2nd place). The conversion formula for converting CGPA to the corresponding Percentage of Marks will be as follows: X = 10 Y - 4.5 where, X = Percentage of Marks & Y = CGPA

1. **Further Clarification**

A student who is promoted to a higher semester or readmitted to a semester due to shortage of attendance shall be required to study the same syllabus as being taught in that year.

1. **Syllabus**

The syllabi for the various PG programmes shall be framed by the Department/ School concerned.

1. **Ranking to the candidates**

Ranking shall be given to only those candidates who pass all the courses of the programme in one attempt.

Notwithstanding any provision in the ordinances to the contrary, the following category of examinee is also eligible for ranking:

The student who, having been duly admitted to a regular examination of the programme, was unable to take that examination in full or in part due to some disruption of examination, and took the next following examination of that programme and passed the course(s).

The marks obtained by him/her at the examination shall be considered as the basis for the University Ranking, Scholarships and other distinctions.

In order to get the benefit of this provision, the student should claim that he/she is eligible for this benefit and get a decision in writing after proving his/her eligibility therefore.

1. **Re-admission to the Programme/semester**

A student who does not put in at least the minimum percentage of attendance required in the Ist semester shall not be promoted to the higher semesters. However, such students can take fresh admission after appearing in the Entrance Examination of this course and being eligible for admission in the course on the basis of result of the Entrance test of the concerned year.

All such students of IInd, IIIrd, IVth, Vth or VIth semesters who have not put in the required minimum percentage of attendance or not filled in the examination form in time shall have the option to be re-admitted in the concerned semester available in the subsequent year(s). No student who has been promoted to the IInd or higher semester and continues to be a student shall be allowed to reappear in the Entrance examination of the same programme for taking fresh admission in the programme.

1. **Break in the Course**

Any student taking admission in M.Sc. STATISTICS AND COMPUTING shall not be allowed to pursue any other full time programme/ course in the Banaras Hindu University or elsewhere in the entire period of the programme meaning thereby that if a student leaves the programme after passing some of the semesters/ courses and takes up a full-time programme/ course elsewhere, then he/she shall not be allowed to continue the programme further.

1. **Definition**
   * + A ‘Regular Student’ is one who has pursued a regular programme of study and obtained prescribed attendance mentioned in the ordinances and is eligible to appear in the examination.
     + ‘Ex-student’ means one who has studied in the Faculty/MMV for at least one semester preceding the date of the examination and had filled up the examination form but failed or had failed to appear in the examination, though otherwise eligible.

**Note: *Academic calendar for the odd and even semesters shall be notified at the beginning of every academic year.***

**M.Sc. in STATISTICS AND COMPUTING**

1. The Post Graduate Course in STATISTICS AND COMPUTING shall be a Two – Year Degree Course comprising of FOUR SEMESTERS (Two Semesters in each year). The total credits including all the four semesters will be 80 including Minor Elective Papers.

1. There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper (Core Courses, Major and Minor Elective papers) except Paper No. MSMS - 307: **Project based on visit to Industries and Research Centers-I** in Semester – III and MSMS - 407: **Project based on visit to Industries and Research Centers-II** in Semester – IV.
2. Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions.
3. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions.
4. Each Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce.
5. All the practical papers shall be of FOUR HOURS duration.
6. In Paper No. MSMS - 307: **Project based on visit to Industries and Research Centers-I** in Semester – III and MSMS - 407: **Project based on visit to Industries and Research Centers-II** in Semester – IV will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce.
7. Two MINOR ELECTIVE THEORY papers (one in each of the semesters – II and III) will be offered by the students of other departments of the faculty, who are not pursuing Post – Graduation in **STATISTICS AND COMPUTING**.

The titles, contents of theory papers as well as practical papers and distribution of credits to papers shall be as follows :

**Proposed Course for M. Sc. in STATISTICS AND COMPUTING**

**DST-CENTRE FOR INTERDISCIPLINARY MATHEMATICAL SCIENCES (CIMS),**

**BANARAS HINDU UNIVERSITY, VARANASI**

**Distribution Of Different Courses And Credits In Various Semesters**

|  |  |  |
| --- | --- | --- |
| **SEMESTER - I** | | |
| **Course Code** | **Title** | **Credit** |
| MSMS-101 | **Statistical Inference-I** | 3 |
| MSMS-102 | **Measure and Probability Theory** | 3 |
| MSMS-103 | **Sampling Techniques and Designs of Experiment** | 3 |
| MSMS-104 | **Functions & Numerical Computing** | 3 |
| MSMS-105 | **Computing with R** | 3 |
| MSMS-106 | **Practical based on above papers** | 4 |
| **Total** | | **19** |
| **SEMESTER - II** | | |
| **Course Code** | **Title** | **Credit** |
| MSMS – 201 | **Data Mining & Statistical Pattern Recognition** | 3 |
| MSMS – 202 | **Statistical Inference-II** | 3 |
| MSMS – 203 | **Multivariate Analysis** | 3 |
| MSMS - 204 | **Distribution Theory & Stochastic Process** | 3 |
| MSMS – 205 | **Programming with SAS** | 3 |
| MSMS – 206 | **Practical based on above Papers** | 4 |
| MSMS-205M | **Minor in Mathematical Science I: Visualizing & Summarizing Data \*** | 2 |
| **Total** | | **21** |
| **SEMESTER - III** | | |
| **Course Code** | **Title** | **Credit** |
| MSMS – 301 | **Decision Theory** | 3 |
| MSMS – 302 | **Numerical recipes in Matrix Algebra and Computational Statistics I** | 3 |
| MSMS – 303 | **Applied Regression Analysis-I** | 3 |
| Any TWO papers out of the Paper Nos. MSMS – 304 to MSMS – 306 | | |
| MSMS – 304 | **Biostatistics –I** | 3 |
| MSMS – 305 | **Business Statistics** | 3 |
| MSMS – 306 | **Engineering Statistics** | 3 |
| MSMS – 307 | **Practical based on above papers** | 4 |
| MSMS-305M | **Minor in Mathematical Science II: Exploratory Data Analysis\*** | 2 |
| **Total** | | **21** |
| **SEMESTER - IV** | | |
| **Course Code** | **Title** | **Credit** |
| MSMS – 401 | **Bayesian Statistics** | 3 |
| MSMS – 402 | **Computational Statistics II** | 3 |
| MSMS – 403 | **Applied Regression Analysis-II** | 3 |
| Any ONE paper out of the Paper Nos. MSMS – 404 & MSMS – 405 | | |
| MSMS – 404 | **Biostatistics –II** | 3 |
| MSMS – 405 | **Official Statistics** | 3 |
| MSMS - 407 | **Practical based on above papers** | 3 |
| MSMS – 408 | **Project based on visit to Industries and Research Centers-II** | 4 |
| **Total** | | **19** |
| **GRAND TOTAL** | | **80** |

**\*** 1. For non-statistics students only. 2. Minor Elective for students of other programmes. 3. Students of Actuarial Science shall offer Minor Electives from other programmes for these 2 credit points.

There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper except Paper No. MSMS - 307: **Project based on visit to Industries and Research Centers-I** in Semester – III and MSMS - 407: **Project based on visit to Industries and Research Centers-II** in Semester – IV.

Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions.

The course contents of different papers are as follows:

# **SEMESTER I**

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| MSMS-101 | **Statistical Inference-I** | Credit: 3 |

Cramer-Rao inequality and its extension for multi-parameter case, concept of information in data about the parameters as variation in likelihood function.

Sufficiency, completeness sufficiency, unbiased estimation, Rao-Blackwell and Lehman-Scheffe theorems, examples based on some standard distributions.

Asymptotic properties of maximum likelihood estimators, method of scoring.

General decision problems, loss function, risk function, estimation and testing viewed as general decision problems, minimax and Bayes decision rules, least favourable prior, Bayes estimation under squared error loss, some simple illustrations based on binomial, Poisson, and normal distributions, procedure for obtaining minimax estimators from Bayes estimators.

**Books Recommended:**

1. B.K. Kale, A First Course on Parametric Inference, Narosa Publishing House, 1999.
2. V.K. Rohatgi, An Introduction to Probability and Mathematical Statistics, Wiley Eastern (New Delhi), 1988.
3. E.L. Lehmann, Theory of Point Estimation, Student Edition, J. Wiley (NY), 1983.
4. E.L. Lehmann, Testing Statistical Hypotheses, 2nd ed., J. Wiley (NY), 1986.
5. C.R. Rao, Linear Statistical Inference and its Applications, Wiley Eastern, 1973.

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| MSMS-102 | **Measure and Probability Theory** | Credit: 3 |

Classes of sets, fields, sigma fields, minimal sigma field, Borel sigma field, sequence of sets, lim sup and lim inf of a sequence of sets, measure, probability measure, properties of measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue - Steiltzes measures.

Measurable functions, random variables, sequence of random variables,. Integration of a measurable function with respect to a measure, monotone convergence theorem, Fatou’s lemma, dominated convergence theorem. Characteristic function, uniqueness theorem, Levy’s continuity theorem (statement only), Convergence in distribution, Convergence in probability, almost sure convergence.

Borel-Cantelli lemma, independence, weak law and strong law of large numbers for independently and identically distributed sequences.

CLT for a sequence of independent random variables under Lindeberg’s condition, CLT for independently and identically distributed random variables.

**References :**

1. Robert, A. (1972): Real Analysis and Probability, Academic press.
2. Billingsley, P. (1989): Probability and Measure, Wiley.
3. Dudley, R.M. (1989): Real Analysis and Probability, Wadsworth and Books.
4. Kingman, J.F.C. and Taylor, S.J. (1966): Introduction to Measure and Probability, Cambridge University Press.

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| MSMS-103 | **Sampling Techniques and Designs of Experiment** | Credit: 3 |

Basic concepts of sampling from a finite population; sampling versus complete enumeration; simple random sampling; sample size determination; stratified random sampling; systematic sampling; cluster sampling and multi – stage sampling ( all sampling schemes without proof of expressions ).

One way and two way classified data. Randomization, replication, local control; completely randomized design; randomized block design and Latin square design; factorial experiments. Missing plot technique, Analysis of Co-variance for CRD and RBD with the concomitant variable.

Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible designs.

General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2n and 3r factorial experiments in randomized blocks; complete and partial confounding, construction and analysis of symmetrical confounded factorial experiments, split plot experiments.

**Books Recommended:**

1. A. Dean and D. Voss, Design and Analysis of Experiment, Springer, 1999.
2. M. Das and N. Giri, Design and Analysis of Experiments, Wiley Eastern, 1979.
3. D.D. Joshi, Linear Estimation and Design of Experiments, Wiley Eastern, 1987.
4. C.D. Montgomery, Design and Analysis of Experiment, Wiley, 1976.
5. W.G. Cochran, Sampling Techniques, 3rd Edition, Wiley, 1977.

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| MSMS-104 | **Functions & Numerical Computing** | Credit: 3 |

Sequence and series, convergence, Bolzano Weirstrass theorem, Continuity and Uniform Continuity, Differentiability, Mean value theorem, Sequence and series of functions, uniform convergence. Functions of several variable, directional derivative, partial derivative, derivative as a linear transformation.

Review of Computation of the zeros of Special function, bisection method, Newton-Raphson method

Approximation of functions, Fourier Approximation. Gauss quadrature.

Differential equations and Frobenius series solutions, Singular points, Power series expansion around a regular singular point, Gauss hypergeometric function, Bessel functions.

**Note:** Emphasis will be laid on writing algorithm and corresponding computer programs.

**Books Recommended:**

1. J.A. Gil and N.M. Temme, Segura and Numerical methods for special functions, Society for Industrial and Applied Mathematics, 2007.
2. S.D. Conte and C. De Boor, Elementary Numerical Analysis: An Algorithmic Approach, McGraw Hill, 1980.
3. W.H. Press, S.A. Teukolsky, W.T. Vellering and B.P. Flannery, Numerical Recipes in C, Second edition, Cambridge University Press, 1993.
4. S.S. Sastry, Introductory Method of Numerical Analysis, PHI Learning Pvt. Ltd, Delhi, 2013.
5. Tom M. Apostol, One-variable calculus with an introduction to linear algebra-Vol. 1, Wiley India, 2007.
6. Tom M. Apostol: Multi-variable calculus and linear algebra with applications to differential equations and probability, Wiley India, 2007.

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| MSMS-105 | **Programming and Computing with R** | Credit: 3 |

Overview of R, R data types and objects (vector, matrix, data frame, list, array, factor, time series), reading and writing data (both from console and external files) and different types of indexes in R.

Control structures; conditional and unconditional transfers, implicit looping (apply, lapply, tapply, etc.), explicit looping (for, while and repeat) and built in constructs (next and break statement).

Functions and Functional Programming, Function Objects and Function Calls, Scoping Rules in R, mutable state, recursive function, list of functions and function factories.

Introduction to object oriented programming in R, overview S4 and S3 classes and difference between them.

Calling external programs in R and linking to data bases. Data visualization using R (both two and three dimensions).

Statistical Computing and mathematical computing based on descriptive statistics, multivariate data representation, simple hypothesis test, analysis of variance, numerical integration, root extraction, matrix computations, etc.

**Books Recommended:**

1. John Chambers, Software for Data Analysis: Programming with R, Springer, 2008.
2. Phil Spector, Data Manipulation with R, Springer, 2008.
3. [Hadley Wickham](https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Hadley+Wickham%22), Advanced R, [Chapman & Hall/CRC The R Series](https://www.google.co.in/search?tbo=p&tbm=bks&q=bibliogroup:%22Chapman+%26+Hall/CRC+The+R+Series%22&source=gbs_metadata_r&cad=2), 2014
4. W.H. Press, S.A. Teukolsky, W.T. Vellering and B.P. Flannery, Numerical Recipes in C, Second edition, Cambridge University Press, 1993.
5. R.A. Thisted, Elements of Statistical Computing, Chapman and Hall, 1988.

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| MSMS-106 | **Practical based on above papers** | Credit: 4 |

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce. The duration of the paper shall be FOUR HOURS).

# **SEMESTER II**

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| MSMS – 201 | **Data Mining & Statistical Pattern Recognition** | Credit: 3 |

Introduction to data mining applications including data preparation and data warehousing, Data Mining and its importance and purposes, Advantages and disadvantages of data mining and data ware housing,

Data Mining Functionalities: Association Analysis, Classification and Prediction, Cluster Analysis, Outlier Analysis, Evolution Analysis, Major issues in Data Mining, CRISP Data Mining and KDD process.

Difference between Data Mining, Data Warehouse, OLAP and DBMS, Characteristics of data ware houses, Data Modeling for data ware houses.

Data Preprocessing: Data cleaning, Data Integration and Transformation, Data Reduction.

Data Mining Primitives, Architectures of Data Mining Systems.

Mining Association Rules in Large Databases: Association Rule Mining, Mining Single-Dimensional Boolean Association Rules from Transactional Database, Mining multilevel association rules from transaction databases, constraint based association mining.

Classification and Prediction: Issues, Classification by Decision Tree induction, Prediction.

High Performance Data Mining.

**Books Recommended:**

1. R.O. Duda and P.E. Hart, Pattern Recognition and Scene Analysis, Wiley, 1973.
2. K. Fukunga, Introduction to Statistical Pattern Recognition. 2nd ed., Academic Press, 1990.
3. G.J. McLachlan, Discriminant Analysis and Statistical Pattern Recognition, Wiley, 1992.
4. B.D. Riple, Pattern Recognition and Neural Networks. Cambridge University Press, 1996.
5. Jiawei Han and MichelineKamber, “Data Mining: Concepts and Techniques”, Academic Press, © 2001 by Academic Press.
6. Arun K Pujari, “Data Mining Techniques”, Universities Press (India) Ltd., Hyderabad 2001, First Edition

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| MSMS – 202 | **Statistical Inference-II** | Credit: 3 |

Consistent Asymptotic Normal (CAN) estimators and their properties, CAN estimators obtained by ML method in one parameter exponential case, Invariant estimators, location and scale invariant estimators, Pitman’s method for obtaining location and scale invariant estimators. Interval estimation by confidence sets, Neyman theory, general method for constructing confidence intervals, shortest confidence intervals, uniformly most accurate intervals, Bayes intervals with simple examples.

Neyman-Pearson lemma, generalized Neyman-Pearson lemma, monotone likelihood ratio families, UMP tests for one and two sided alternatives, admissibility and unbiasedness of tests, type A and type A1 tests, similar tests, tests having Neyman structure, likelihood ratio test (LRT) asymptotic distribution of LRT statistic.

Wald’s sequential probability ratio test and its properties, OC and ASN function, derivation of OC and ASN functions.

**Books Recommended:**

1. B.K. Kale, A First Course on Parametric Inference, Narosa Publishing House, 1999.
2. V.K. Rohatgi, An Introduction to Probability and Mathematical Statistics, Wiley Eastern (New Delhi), 1988.
3. E.L. Lehmann, Theory of Point Estimation, Student Edition, J. Wiley (NY), 1983.
4. E.L. Lehmann, Testing Statistical Hypotheses, 2nd ed., J. Wiley (NY), 1986.
5. C.R. Rao, Linear Statistical Inference and its Applications, Wiley Eastern, 1973.

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| MSMS – 203 | **Multivariate Analysis** | Credit: 3 |

Multivariate normal distribution and its properties. Random sampling from multivariate normal distribution. Maximum likelihood estimators of parameters, distribution of sample mean vector.

Wishart matrix – its distribution and properties, distribution of sample generalized variance, null and non-null distribution of multiple correlation coefficients. Hotelling’s T2 and its sampling distribution, application in test on mean vector for one and more multivariate normal population and also on equality of components of a mean vector in multivariate normal population.

Classification problem- Standards of good classification, procedure of classification based on multivariate normal distributions. Principal components, dimension reduction, canonical variates and canonical correlation—definition, use, estimation and computation.

**Books Recommended:**

1. T.W. Anderson, An Introduction to Multivariate Statistical Analysis, 2nd Ed., Willey, 1983.
2. N.C. Giri, Multivariate Statistical Inference, Academic Press, 1977.
3. A.M. Kshirsagar, Multivariate Analysis, Marcel Dekker, 1972.
4. D.F. Morrison, Multivariate Statistical Methods, 2nd Ed. McGraw Hill, 1976.
5. R.J. Muirhead, Aspects of Multivariate Statistical Theory, J. Wiley, 1982.

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| MSMS – 204 | **Distribution Theory & Stochastic Process** | Credit: 3 |

Compound, truncated and mixture distributions, Markov, Holder, Jensen, Liapunov inequalities.

Order statistics, their distributions and properties, joint and marginal distributions of order statistics, extreme values and their asymptotic distributions (statement only) with applications.

Stochastic Processes- concept and classification. Markov chains (MC’s), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Stationary distribution, classification of states; transient MC; random walk and gambler’s ruin problem; Applications from social, biological and physical sciences. Kolmogorov – Feller differential equations; Poisson process, birth and death process; Wiener process as a limit of random walk; first-passage time and other problems. Elementary renewal theorem and applications. Residual life time process. Stationary process; Galton-Watson branching process, probability of ultimate extinction, distribution of population size. Martingales in discrete time, inequality, convergence and smoothing properties.

**Books Recommended:**

1. V.K. Rohatgi, An Introduction to Probability and Mathematical Statistics, Wiley Eastern (New Delhi), 1988.
2. C.R. Rao, Linear Statistical Inference and its Applications, Wiley Eastern, 1973.
3. J. Pitman, Probability, Narosa Publishing House, 1993.
4. S. Jonson and S. Kotz, Distribution in Statistics, Vol. I, II & III, Houghton and Mifflin, 1972.
5. E. Cinlar, Introduction to Stochastic Processes, Prentice Hall, 1975.
6. T.E. Harris, The Theory of Branching Processes, Springer-Verlag, 1963.
7. P.G. Hoel, S.C. Port and C.J. Stone, Introduction to Stochastic Processes, Houghton Miffin & Co., 1972.

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| MSMS – 205 | **Programming with SAS** | Credit: 3 |

Basics of SAS Programming: Introduction of SAS Environment, SAS Programing Language & SAS Data Sets, Two Steps in SAS Programming, DATA Step’s Built-in Loop, Various ways of output in SAS, SAS System Options, Reading Raw Data in various forms, Various components of an INPUT statement to process raw data files including column and line pointer controls and trailing @ controls, Reading CSV files, DDE, Temporary versus Permanent SAS Data Sets, CONTENTS procedure.

Managing Data through SAS: Creating Variables, SAS numeric Functions, date functions, character functions, Subsetting Data with IF-THEN/ELSE Statements, DO END statements, Handling Dates in SAS, Sum Statements, Arrays in SAS, DO Loops, Various Informats & Formats.

Summarizing data with SAS Procedures: Use of conditional statement like WHERE Statement and commonly used procedures like SORT Procedure, FORMAT Procedure, MEAN Procedure, FREQ Procedure, TABULATE procedure etc., Enhancing output using ODS

Basic Graphical and Statistical Procedures: Using SAS procedures like PLOT, SGPLOT, UNIVARIATE, CORR, REG etc. for reporting and statistical analysis by examining data and plotting relevant graphs, Using PROC ANOVA for One-Way Analysis of Variance, Using CHART procedure.

# Books Recommended:

1. N. Spencer, SAS Programming: The One-Day Course, Chapman & Hall/CRC Press, 2004.
2. L. D. Delwiche and S.J. Slaughter, The Little SAS Book: A Primer, SAS Institute, 2008
3. A. J. Bailer, Statistical Programming in SAS, SAS Institute, 2010.
4. Step-by-Step Programming with Base SAS® Software, SAS® Publishing, 2001

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| MSMS – 206 | **Practical based on above Papers** | Credit: 4 |

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce. The duration of the paper shall be FOUR HOURS).

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| MSMS -205M | **Minor in Mathematical Science I: Visualizing & Summarizing Data** | Credit: 2 |

(For non-statistics students)

Power and challenges of graphical display: clear vision, clear display, scaling.

Graphical methods: logarithms, residuals, distributions, dot, bar and box plots, plotting symbols and curve types, time series plots, scatter matrices, codplots of scattered data and surfaces, statistical variation.

Graphical perception: Models, superposed curves, colour encoding, texture symbols, correlation, pop charts, graphing along a common scaling.

1. F. Hartwig and B.E. Dearing, Exploratory Data Analysis, Sage Publications, 1979.
2. John W. Tukey, Exploratory Data Analysis, Addison-Wesley, 1997.

# **SEMESTER III**

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| MSMS – 301 | **Decision Theory** | Credit: 4 |

Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles (conditional Bayes, frequentist), inference problems as decision problems, optimal decision rules.

Concept of admissibility and completeness, Bayes rules, admissibility of Bayes rules.

Supporting and separating hyperplane theorems, minimax theorem of for finite parameter s pace, minimax estimators of Normal and Poisson means, admissibility of minimax rules.

Invariant decision rules – location parameter problems, invariance and minimaxity , admissibility of invariant rules, complete class theorem, complete and essentially complete classes in simple estimation and testing situations, estimation of a distribution function.

Sufficient statistics, essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

Sequential decision rules, Bayes and minimax sequential decision rules, invariant sequential decision problems.

**Books Recommended:**

1. J.O. Berger, Statistical Decision Theory and Bayesian Analysis, 2nd ed., Springer-Verlag, 1985.
2. T.S. Ferguson, Mathematical Statistics – A Decision Theoretic Approach, Academic Press, 1967.
3. C.P. Robert, The Bayesian Choice, Springer, 2001.
4. J.M. Bernando and A.F.M. Smith, Bayesian Theory, John Wiley and Sons, 1994.

V.K. Rohatgi, An Introduction to Probability and Mathematical Statistics, Wiley Eastern (New Delhi), 1988.

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| **MSMS 302** | **Numerical recipes in Matrix Algebra and Computational Statistics I** | **Credit: 4** |

Algebra of matrices, rank and determinant of matrices, linear equations, Eigenvalues and eigenvectors, Cayley Hamilton theorem, Vector Space and linear transformation, matrix representation of linear transformations, Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Linear product spaces, orthogonal basis. Quadratic forms, reduction and classification of quadratic forms.

Exploratory data analysis, Role of graphics in data exploration, dealing with outliers, Transforming Data

EM algorithm: definition, censored exponentially distributed survival times, E and M steps for regular exponential families, applications to missing and incomplete data problems, generalized EM algorithm, bivariate and multivariate normal data with missing values, finite mixture models

Density estimation, the naive estimator, kernel estimator, smoothing with kernels

1. G.J. McLachlan and T. Krishnan, The EM Algorithms and Extensions, Wiley, 1997.
2. B. Efron and R.J. Tibshirani, An Introduction to the Bootstrap. Chapman & Hall, 1994.
3. Nabil Nassif, Jocelyne Erhel, Bernard Philippe, Introduction to Computational Linear Algebra, Chapman and Hall/CRC, 2015.
4. J Phillipe G Ciarlet, Introduction to Numerical Linear Algebra and Optimization. Cambridge University Press, 1989
5. B.W. Silverman, Density Estimation for Statistics and Data Analysis, Chapman & Hall, 1986
6. D. C. Hoaglin and F. Mosteller, [Understanding Robust and Exploratory Data Analysis, Wiley Inter-Science, 2000](https://www.amazon.com/Understanding-Robust-Exploratory-Data-Analysis/dp/0471384917/ref=sr_1_2?s=books&ie=UTF8&qid=1488470117&sr=1-2&keywords=exploratory+data+analysis+tukey).
7. John W. Tukey, Exploratory Data Analysis, Pearson; 1 edition, 1977.

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| MSMS – 303 | **Applied Regression Analysis-I** | Credit: 4 |

Basics of linear regression with one and multiple predictors, graphical display of data and fitted models.

Statistical inference in MLR under assumptions of normality and independence. Test of goodness of fit of a model and choice of a regression model.

Definition of heteroscedasticity, multicollinearity, correlated errors or autocorrelation and testing the above.

Linear transformations, centering and standardizing, Logarithmic and other transformations.

Non-linear regression models, different methods of estimation (Least Squares, Maximum Likelihood) Asymptotic properties of estimators.

Simulation of samples from uniform and other random variables and statistical test of goodness of fit.

**Books Recommended:**

1. S. Weisberg, Applied Linear Regression, 2nd Edition, J.Wiley & Sons, 1985.
2. N.R. Draper and H. Smith, Applied Regression Analysis, Wiley, 1998
3. J.O. Rawlings, Applied Regression Analysis, Springer-Verlag, 2001.
4. M.H. Kunter, Applied Linear Statistical Models, McGraw-Hill, 2005.
5. M.H. Kunter, C. Nachtsheim and J. Neter, Applied Linear Regression Models, McGraw-Hill, 2004.
6. D.N. Gujarati, Basic Econometrics, Tata McGraw-Hill Publishing Co. Ltd. New Delhi, 2004.
7. G.B. Wetherill et al., Regression Analysis with Applications, Chapman and Hall, London & NewYork, 1986.

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| MSMS – 304 | **Biostatistics –I** | Credit: 3 |

Epidemiology:

Concept of Health, Theories of diseases causations , Levels of prevention, Introduction to epidemiology, Aims of Epidemiology, General epidemiology of infectious and non-infectious disease, Measurements in Epidemiology: Tools of measurement in epidemiology, measurements of morbidity, measurements of mortality, disability etc. Epidemiological study designs: Descriptive studies, cross-sectional studies, case study, case series studies, and ecological studies. Analytical studies: case control studies, prospective studies and its types, Calculation of Epidemiological parameters in various study designs, Screening for diseases, Surveillance and Monitoring.

Clinical Trail:

Evidence based medicine, Randomized clinical trial (RCT):i. Need of clinical trial, Phases of clinical trial, ii. Types of clinical trial (Based on study design (parallel and cross-over design, cluster design, Factorial), By Hypothesis (Superiority, equivalence and non-inferiority trial), By outcome of interest (efficacy vs effectiveness), iii. Principles of sample size calculation, different types of study designs and sample size calculation, iv. Analysis of outcome variables, Biases and random error in clinical studies, multicentre and multinational studies, Steps of an RTC (Writing a protocol): selection of study subjects, randomization of study subjects into control and intervention groups, simple and block randomization, stratified randomization, Ethical issues in clinical trials, Informed consent form, Case Report Form, Data collection system for 'Good Clinical Practice'.

**Books Recommended:**

1. K. J. Rothman and S. Geenland (ed.) (1988). Modern Epidemiology, Lippincott-Raven.
2. S. Selvin (1996). Statistical Analysis of Epidemiologic Data, Oxford University Press.
3. D. McNeil (1996). Epidemiological Research Methods. Wiley and Sons.
4. J. F. Jekel, J. G. Elmore, D.L. Katz (1996). Epidemiology, Biostatistics and Preventive Medicine. WB Saunders Co.
5. S. Piantadosi (1997): Clinical Trials: A Methodologic Perspective. Wiley and Sons.
6. C. Jennison and B. W. Turnbull (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
7. L. M. Friedman, C. Furburg, D. L. Demets (1998): Fundamentals of Clinical Trials Springer Verlag.
8. J. L. Fleiss (1989): The Design and Analysis of Clinical Experiments. Wiley and Son.
9. E. Marubeni and M. G. Valsecchi (1994): Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

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| MSMS – 305 | **Business Statistics** | Credit: 3 |

Decisions under Certainty, Risk and Uncertainty. Decision Criteria. Minimax, Maximin, Maximax and Baye’s Criteria.

Time series analysis – economic time series; different components; illustrations; additive and multiplicative models; determination of trend; growth curves; analysis of seasonal fluctuations; construction of seasonal indices.

Time-series as discrete parameter stochastic process, auto covariance and autocorrelation functions and their properties.

Exploratory time Series analysis, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting based on smoothing.

**Books Recommended:**

1. P. Mukhopadhyay, Applied Statistics, New Central Book Agency Pvt. Ltd. (Calcutta), 1995.
2. O.S. Srivastava, A Text Book of Demography, Vikas Publishing House, New Delhi, 1991.
3. A.M. Goon, M.K. Gupta and B. Das Gupta, Fundamentals of Statistics, Vol. II, World Press, (Calcutta), 1991.
4. R.G. Brown, Smoothing, Forecasting and Prediction of Discrete Time Series, Prentice Hall, 1963.
5. C. Chatfield, The Analysis of Time Series – An Introduction, 2nd ed., Chapman and Hall, 2004.

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| MSMS – 306 | **Engineering Statistics** | Credit: 3 |

Reliability: Scope and related measures.

System Reliability: Series, parallel, k-out of- n and related configurations; Bridge configurations; Reliability analysis using Markov model.

Reliability Improvement: Redundency, Active/load sharing and Passive redundancy; Preventive maintenance and its methods; Reliability Allocations.

Basic concepts of process monitoring and control; process capability and process optimization. General theory and review of control charts for attribute and variable data; O.C. and A.R.L. of control charts; control by gauging; moving average and exponentially weighted moving average charts; Cu-Sum charts using V-masks and decision intervals; Economic design of X-bar chart.

Acceptance sampling plans for attributes inspection; single and double sampling plans and their properties. Sequential Sampling plan and Bayesian Sampling Plan.

**Books Recommended:**

1. D.C. Montgomery, Introduction to Statistical Quality Control, Wiley, 1985.
2. E.R. Ott, Process Quality Control, McGraw Hill, 1975.
3. M.S. Phadke, Quality Engineering Through Robust Design; Prentice Hall, 1989.
4. G.B. Wetherill, Sampling Inspection and Quality Control, Halsted Press, 1977.
5. G.B. Wetherill and D.W. Brown, Statistical Process Control: Theory and Practice, Chapman & Hall, 1991.
6. R.E. Barlow and F. Proschan, Statistical Theory of Reliability and Life testing; Holt, Rinehart and Winston.

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| MSMS – 307 | **Practical based on above papers** | Credit: 4 |

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce. The duration of the paper shall be FOUR HOURS).

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| MSMS -305M | **Minor in Mathematical Science II: Exploratory Data Analysis** | Credit: 2 |

(For non-statistics students)

Exploratory perspective, Looking at Data: distribution of single variables, displaying data, summarizing data, Stem and Leaf, Box and Whisker, Understanding data, skewness, outliers, gaps and several peaks.

Displaying and summarizing relationship: scatter plot, fitting a line, smoothing data, median and hinge traces, nonlinear relationship.

Looking for structure: choosing appropriate expression, nonlinear monotonic and non-monotonic functions.

Univariate, bivariate, multivariate causal analysis: objectives and main concepts.

1. F. Hartwig and B.E. Dearing, Exploratory Data Analysis, Sage Publications, 1979.
2. John W. Tukey, Exploratory Data Analysis, Addison-Wesley, 1997.

# **SEMESTER IV**

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| MSMS – 401 | **Bayesian Statistics** | Credit: 3 |

Subjective probability, its existence and interpretation. Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors. Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, mixtures of conjugate priors, hierarchical priors and partial exchangeability. Parametric Empirical Bayes.

Bayesian inference: Bayes sufficiency, summary through posterior, predictive inference.

Bayesian decision theory : Bayes solutions for practical decision problems. Point estimation, credible sets, testing of hypotheses. Comparison with classical procedures. Admissibility and minimaxity of Bayes and generalized Bayes procedures.

Ideas on Bayesian robustness. Asymptotic expansion for the posterior density. Bayesian calculation, Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof).

# Books Recommended:

1. J.O. Berger, Statistical Decision Theory and Bayesian Analysis, 2nd ed., Springer-Verlag, 1985.
2. T.S. Ferguson, Mathematical Statistics – A Decision Theoretic Approach, Academic Pres, 1967.
3. CP. Robert, The Bayesian Choice: A Decision Theoretic Motivation, 2nd ed., Springer, 2001.
4. J.M. Bernando and A.F.M. Smith, Bayesian Theory, John Wiley and Sons, 1994

G.P. Box and G.C. Tiao, Bayesian Inference in Statistical Analysis, Addison-Wesley, 1973.

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| MSMS – 402 | **Computational Statistics II** | Credit: 3 |

Stochastic simulation: generating random variables, simulating standard univariate and multivariate distributions.

Variance reduction: importance sampling for integration, control variates and antithetic variables.

Markov Chain Monte Carlo Methods: Gibbs sampling for standard distributions, Metropolis algorithm

Simulation based testing: simulating test statistics and power functions, permutation tests.

Bootstrap methods: parametric and non-parametric bootstrap, resampling paradigms, bias and standard errors, confidence intervals.

Jackknife and cross validation.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

# References:

1. G.S. Fishman (1996): Monte Carlo: Concepts, Algorithms, and Applications, Springer.
2. R.Y. Rubinstein (1981): Simulation and the Monte Carlo Method, Wiley.
3. M.A. Tanner (1996): Tools for Statistical Interference, Third edition, Springer.
4. B. Efron and R.J. Tibshirani (1993): An introduction to the Bootstrap, Chapman and Hall.
5. J. Shao and D. Tu (1995): Jackknife and the Bootstrap, Springer Verlag.

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| MSMS – 403 | **Applied Regression Analysis-II** | Credit: 3 |

Residuals and their analysis for detection of violation of independence, normality, homoscedasticity and inadequacy of fitted model.

Power transformations for response and explanatory variables.

Types of outliers, Measures and tests of leverage and influence points.

Generalized linear models, analysis of binary response data using logistic and binomial logistic models. Interaction in logistic model.

Poisson regression or log-linear model. Method of choosing logistic or log-linear model.

Ordered and unordered categorical regression. Robust regression.

Estimation of prediction error by cross-validation and bootstrap. Bayes analysis of linear and generalized linear models.

# Books Recommended:

1. D.M. Bates and D.G. Watts, Nonlinear Regression, Analysis and its Application, Wiley (New York), 1988.
2. R.D. Cook and S. Weisberg, Residuals and Inference in Regression, Chapman and Hall, 1982.
3. N.R. Draper and H. Smith, Applied Regression Analysis, 3rd Ed., Willey, 1998.
4. P. McCullagh and J.A. Nelder, Generalized Linear Models, 2nd Ed., Chapman and Hall, 1989.
5. G.A. Seber and G.J. Wild, Nonlinear Regression, Wiley, 1989.
6. D.N. Gujarati, Basic Econometrics, Tata McGraw-Hill Publishing Co. Ltd. New Delhi, 2004.
7. G.B. Wetherill et al., Regression Analysis with Applications, Chapman and Hall, 1986.
8. Jürgen Groβ, Linear Regression. Springer Verlag, 2003.

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| MSMS – 404 | **Biostatistics –II** | Credit: 3 |

Concept of time, order and random censoring, likelihood in the distributions – exponential, gamma, Weibull, lognormal, Pareto, Linear failure rate, inference for these distribution.

Life tables, failure rate, mean residual life and their elementary classes and their properties.

Estimation of survival function – actuarial estimator, Kaplan – Meier estimator, estimation under the assumption of IFR/DFR.

Two sample problem – Gehan test, log rank test.

Semi-parametric regression for failure rate – Cox’s proportional hazards model with one and several covariates. rank test for the regression coefficient.

Competing risk model, parametric and non-parametric inference for this model.

Bayesian Analysis of medical data-use of prior probabilities and predictive inferences.

**References:**

1. Barlow, R.E. and Proschan, F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data; John Wiley.
3. Nelson, W. (1982): Applied life Data Analysis; John Wiley.
4. Zacks, S.: Reliability Theory; Springer
5. Bain, L. J. and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

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| MSMS – 405 | **Official Statistics** | Credit: 3 |

### Introduction to Indian and International statistical systems. role, function and activities of central and state statistical organizations, organization of large scale sample surveys, role of national sample survey organization general and special data dissemination systems. Population growth in developed and developing countries, evaluation and performance of family welfare programmes, projections of labour force and manpower, scope and content of population census of India.

System of collection of agricultural statistics, crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

**Books Recommended:**

1. Basic Statistics Relating to the Indian Economy, CSO, 1990.
2. Guide to Official Statistics, CSO, 1999.
3. Statistical System in India, CSO, 1995.
4. V.G. Panse, Estimation of Crop Yields, FAO (Rome), 1964.
5. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.

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| MSMS – 407 | **Practical based on above papers** | Credit: 3 |

(Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce. The duration of the paper shall be FOUR HOURS).

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| MSMS – 408 | **Project based on visit to Industries and Research Centers-II** | Credit: 4 |

(The Project Work will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce).