।। सा विद्या या विमुक्तये ।।
स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड
"ज्ञानतीर्थ" परिसर, विष्णुपूरी, नांदेड - ४३१६०६ (महाराष्ट्र)
SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY NANDED
"Dnyanteerth", Vishnupuri, Nanded - 431606 Maharashtra State (INDIA)
Established on 17th September 1994 – Recognized by the UGC U/s 2(f) and 12(B), NAAC Re-accredited with 'A' Grade
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प्रस्तुत विद्यापीठीय संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे CBCS Pattern नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, **दिनांक २० जून २०२० रोजी संपन्न झालेल्या ४७व्या मा. विद्या परिषद बैठकीतील विषय क्र.११/४७—२०२०** च्या ठरावानुसार **प्रस्तुत विद्यापीठीय संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे** खालील विषयांचे **C.B.C.S. (Choice Based Credit System) Pattern** नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्यात येत आहेत.

01. M.Sc.-II Year-Botany
02. M.Sc.-II Year-Analytical Chemistry
03. M.Sc.-II Year-Industrial Chemistry
04. M.Sc.-II Year-Medicinal Chemistry
05. M.Sc.-II Year-Organic Chemistry
06. M.Sc.-II Year-Physical Chemistry
07. M.Sc.-II Year-Polymer Chemistry
08. M.Sc.-II Year-Computer Application
09. M.Sc.-II Year-Computer Network
10. M.Sc.-II Year-Computer Science
11. M.C.A.-II Year (Master of Computer Applications)
12. M.Sc.-II Year-Environmental Science
13. M.A./M.Sc.-II Year-Geography
14. M.Sc.-II Year-Geophysics
15. M.Sc.-II Year-Geology
16. M.A./M.Sc.-II Year-Mathematics
17. M.Sc.-II Year-Microbiology
18. M.Sc.-II Year-Physics
19. M.Sc.-II Year-Zoology
20. M.Sc.-II Year-Biotechnology
21. M.A./M.Sc.-II Year-Statistics

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.: शैक्षणिक—१/परिपत्रक/पदव्युत्तर(संकुल)—सीबीसीएस अभ्यासक्रम/२०२०—२१/**५१३**

स्वाक्षरित/—
उपकुलसचिव
शैक्षणिक (१—अभ्यासमंडळ) विभाग

दिनांक : ०८.०८.२०२०.

प्रत माहिती व पुढील कार्यवाहीस्तव :
१) मा. कुलसचिव यांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मूल्यमापन मंडळ यांचे कार्यालय, प्रस्तुत विद्यापीठ.
३) मा. संचालक, सर्व संबंधित संकुले, प्रस्तुत विद्यापीठ.
४) साहाय्यक कुलसचिव, पदव्युत्तर विभाग, प्रस्तुत विद्यापीठ.
५) उपकुलसचिव, पात्रता विभाग, प्रस्तुत विद्यापीठ.
६) सिस्टम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ.

Swami Ramanand Teerth Marathwada University, Nanded
School of Mathematical Sciences

Two Year M. A. / M. Sc. Degree Program in Statistics

Revised Syllabi of M. A. / M. Sc. in Statistics

(Choice Based Credit System)

(To be implemented in the Department of Statistics, Swami Ramanand Teerth Marathwada University, Nanded)

M. A. / M. Sc. in Statistics Second Year

(With effect from Academic Year 2020-2021)

Program Code: SMS-S-STA-PG

Numeric Code: 20-2-2-01

Title of the Program: M. A. / M. Sc. in Statistics

❖ Vision:

To organize, connect, build and communicate statistical concepts effectively through devotion, determination, obedience and path. Contribute subject knowledge to promote the students for development among ethical value-based learning to nurture creativity, research and development.

❖ Mission:

- To enhance the logical and analytical skills in solving problems.
- To inculcate research culture the students.
- To serve as an enabler in Statistics Programme higher education and research that match global benchmarks.
- Adapting to ever-changing needs of the Academics, Banking and industries etc. sector.
- Promoting international understanding through quality education.

1. Preamble/Prerequisites: M. A. / M. Sc. Statistics programme is of minimum 100 credits spread over four semesters. The programme emphasizes both theory and applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics. The program has some unique features such as independent projects, number of elective courses, extensive computer training of statistical computations including standard software packages such as MATLAB, MINITAB, R, TORA and SPSS. The department has the academic autonomy and it has been utilized to add the new and need based elective courses. The independent project work is one of the important components of this program. In this syllabus core courses, electives and open electives are offered. The syllabus has been framed to have a good balance of theory, methods and applications of statistics. It is possible for the students to study basic courses from other disciplines such as economics, life sciences, computer science and mathematics in place of electives. This programme requires basic of data types, organization of data and tabulation of data, Graphical representation, data transformation, distribution theory, and sampling methodology.

A course with STATC, STATE, STATPC and STATOE indicates program title, a core theory course indicated by ‘C’; elective theory course indicated by ‘É’; ‘P’ is for practical from semester one to three and fourth semester for Project and OE indicated for Open elect ives respectively. A student can enroll for a practical course if the student has enrolled for the corresponding theory course (as indicated) in the same term.

2. Program Educational Objectives (PEO):

M. A. / M. Sc. Statistics program has semester pattern and credit system with variable credits. The program consists of 100 credits. Credits of a course are specified against the title of the course. The learning objectives of this program are:

PEO1: Students should able to understand, implement and overcome problems through statistical techniques.

PEO2: To develop scientific view among students for better understanding and analytic ability the collected data for specific perspectives.

PEO3: Demonstrate graduate-level skills in communicating mathematics and statistics, orally and in writing.

PEO4: Students should able understand appropriate, relevant, fundamental and applied mathematical; and statistical methodologies and modern computational tools.

PEO5: The ability to bring together and flexibly apply knowledge to characterize, analyze and solve a wide range of problems an understanding of the balance between the complexity / accuracy of the mathematical / statistical models used and the timeliness of the delivery of the solution.

PEO6: Ability to contribute to professional work settings through effective participation in teams and organization of project tasks the ability to constructively engage with other team members and resolve conflict.

PEO7: The ability to communicate effectively in terms of technical and non-technical material in a range forms to different audiences.

4. Program Outcomes (PO):

On successful completion of the program students will able to:

PO1: Have specialised knowledge and understanding of statistical theory at an advanced level which take into account recent advances in the subject.

PO2: Acquire the **s**trong foundation of statistical concepts which will benefit them to become good academicians.

PO3: **U**se acquired statistical methodologies and modelling techniques to address real-life problems.

PO4: Gain the knowledge of software which has the wide range of opportunities in the Quality control, Planning and development, IT sector, R&D in industries, Business, Government and private sector etc.

PO5: Qualify various National / State level competitive exams like ISS, DSO, CSIR-UGC NET, SLET, GATE, MPSC, UPSC, Banking etc.

5. Program Specific Outcomes (PSO):

On successful completion of the program students will able to:

PSO1: Understand, implement and develop statistical models.

PSO2: Handle and analyze small as well as large databases with computer skills.

PSO3: Describe complex statistical ideas to non-statisticians and to present the results of their analyses in written, oral forms and can make practical suggestions for improvement.

PSO4: Get wide range of statistical skills in problem-solving.

PSO5: The project work and presentation may enable to take prominent roles in a wide spectrum of employment and research.

6. Course Outcomes (for all courses):

The course outcomes are the statement that describes the knowledge & abilities developed in the student by the end of course (subject) teaching. The focus is on development of abilities rather than mere content. There are 4 course outcomes of all courses defined here. These are to be written in the specific terms and not in general.

6.1. Set Target levels for Attainment of Course Outcomes:

The course outcome attainment is assessed in order to track the graduates' performance with respect to target level of performance. The CO-PO attainment is the tool used for continuous improvement in the graduates' abilities through appropriate learning & teaching strategies. In order to assess students' performance with respect to abilities (at the end of course teaching/by the end of program) the course outcome attainment are measured/calculated. In order to calculate the program outcome attainment, the course outcome attainment is calculated. Prior to that, the course-program outcome mapping is done.

6.2. Set Target level for Attainment of Program Outcomes:

The program outcome attainment is assessed in order to track the graduates' performance with respect to target level of performance. The CO-PO attainment is the tool used for continuous improvement in the graduates' abilities through appropriate learning and teaching strategies. In order to assess students' performance with respect to abilities (at the end of course teaching/by the end of program) the course outcome attainment and program outcome attainment is measured/calculated. The program outcome attainment is governed by curricular, co-curricular and extra-curricular activities including the stakeholders' participation. The direct method and indirect method is adopted to calculate the PO attainment. The direct method implies the attainment by course outcomes contributing to respective program outcomes. And indirect method is the satisfaction/ feed-back survey of stakeholders. In order to calculate the program outcome attainment, the course outcome attainment is calculated. Prior to that, the course-program outcome mapping is done. The set target level is the set benchmark to ensure the continuous improvements in the learners/ graduates' performance.

6.3. Course Attainment Levels:

a) CO attainment is defined / set at three levels;
b) The CO attainment is based on end term examination assessment and internal assessment;
c) The Co attainment is defined at three levels in ascending order

d) Course Levels:

i) Level-1: 40% students score greater than or equal to class average
ii) Level-2: 50%students score greater than or equal to class average
iii) Level-3: 60%students score greater than or equal to class average

Target Level: Level – 2

e) The target level is set (e.g. Level-2). It indicates that, the current target is level-2; 50% students score more than class average. The CO attainment is measured and the results are obtained. Based on the results of attainment, the corrective measures/remedial action are taken.
f) CO Attainment= 80% (Attainment level in end term examination) + 20% (Attainment level in internal examination).
g) The example of calculating CO attainment is provided for one of the course.

Program attainment Level:

a) PO attainment is defined at five levels in ascending order;

b) The PO attainment is based on the average attainment level of corresponding courses (Direct Method) and feed-back survey (Indirect method);

c) The PO attainment levels are defined / set as stated below;
i) Level-1: Greater than 0.5 and less than 1.0 (0.5>1) - Poor
ii) Level-2: 1.0>1.5-Average
iii) Level-3: 1.5>2.0-Good
iv) Level-4: 2.0>2.5-Very Good
v) Level-5: 2.5>3.0 –Excellent

d) The PO attainment target level is set/defined (say, Level-4). It implies that, the department is aiming at minimum level-4 (very good) in the performance of abilities by the graduates. Based upon the results of attainment, the remedial measures are taken;

e) PO Attainment= 80% (Average attainment level by direct method) + 20% (Average attainment level by indirect method).

For Example:
Course Code/Title: STA-101 REAL ANALYSIS

e.g. For end term and internal examination;
i. Level-1: 40% students scored more than class average
ii. Level-2: 50% students score more than class average;
iii. Level-3: 60% students score more than class average

Average Marks in External examination: 26

% Students score more than 26 is 58/100 i.e. 58.00% i.e. Level-2

Average Marks in Internal examination= 7

% Students score more than 7 is 71/100 i.e.71.00%, i.e. Level-3
A (CO) STA-101 = 80% (2) +20(3)
=1.6+0.6
= 2.2
Hence, the attainment level is Level-2 and the set target level is Level-2 and therefore the CO is fully attained.

7. Eligibility: For M. A. / M.Sc. in Statistics following candidates are eligible.

- B. A. / B. Sc. with Statistics/ Mathematics as a principal subject.

8. Definitions:

Credits:

Credit is a kind of weightage given to the contact hours to teach the prescribed syllabus, which is in a modular form. Normally one credit is allocated to 15 contact hours.

- In each of the courses, credits will be assigned on the basis of the number of lectures / tutorials / laboratory work and other forms of learning required for completing the course contents in maximum 18 week schedule.
- The instructional days as worked out by the UGC for one academic year are 180 working days i.e. 90 days per semester.
- **Mechanics of Credit Calculation:** As per SRTMUN standard, 1Credit= 15 contact hours. 60 Contact hours will include all the modes of teaching like lectures / tutorials / laboratory work / fieldwork or other forms which suits to that particular course. In determining the number of hours of instruction required for a course involving laboratory / field-work, 2 hours of laboratory / field work is generally considered equivalent to 1 hour of lecture.

I. Credit Point (P):

Credit point is the value obtained by multiplying the grade point (G) by the credit (C): P = G x C.

II. Grade Point:

Grade point is an integer indicating the numerical *SEMESTER GRADE POINT AVERAGE (SGPA):*

III. Semester Grade Point Average (SGPA) is the value obtained by dividing the sum of credit points (P) earned by a student in various courses taken in a semester by the total number of credits earned by the student in that semester. SGPA shall be rounded off to two decimal places.

IV. Cumulative Grade Point Average (CGPA):

'Cumulative Grade Point Average' (CGPA) is the value obtained by dividing the sum of credit points in all the courses earned by a student for the entire programme, by the total number of credits. CGPA shall be rounded off to two decimal places. CGPA indicate an overall letter grade (Cumulative Grade) for the entire programme shall be awarded to a student depending on his/her CGPA. The comprehensive academic performance of a student in a programme is equivalent of the letter grade.

➢ **Evaluation System -**

In this section the broad guidelines to be followed in evaluation system and the minimum number of credits to be completed to get a degree are defined.

a. The evaluation will be on Mid Semester Assessment (MSA), End Semester Assessment (ESA). The final results shall be declared after integration of MSA and ESA.
b. Weightage: 50% for End Semester Assessment (ESA) & 50% for Mid Semester Assessment (MSA).

The declaration of result is based on the grade point average (GPA) earned towards the end of each semester or the Cumulative Grade Point Average (CGPA) earned towards the end of the program.

The Post-graduate degree will be awarded to those students who earn the minimum number of Credits. For the award of degree the student has to acquire minimum number of credits as per the table given below.

Name of the Faculty/course	Total credits	Average credits per semester
M.A./ M.Sc.	**100**	**25**

a. One credit will be equivalent to 15 clock hours of teacher-student contact in a semester.

b. Four –credit course of theory will be of four clock hours per week.

c. Three- credit course of practical will be of 6 hours of lab exercise/field.

d. The project will be commencing from Semester III and the final work & report will be completed during Semester IV. The marks & the credits will be allotted in semester IV.

e. There will be no mid-way change allowed from Credit System to Non-credit (external) System or vice versa.

f. Except the credits for practical courses, wherever applicable, a student can register for less number of courses in a semester subject to the condition that such a student will have to complete the degree in a maximum of five, four and two years respectively for three, two and one year programs. This facility will be available subject to the availability of concerned courses in a given semester and with a maximum variation of 25 % credits (in case of fresh credits) per semester.

g. **CBCS**:
Among the minimum number of credits to be earned by a student to complete a Post Graduate degree program (100 credits), the student will have to earn minimum 75% credits from the core subjects and the remaining 25 % credits could be earned from the elective/open elective (inter/intra disciplinary) subjects offered within and across the schools. The maximum number of credits offered across the disciplinary should not exceed 10% of total credits for the program.

The distribution of the courses in a Program: The total number of minimum credits to complete the program is different for different programs. Out of these:

Core: 75% of total credits of the Program of that particular discipline.

Elective: 25% (including discipline specific subject electives and Open (Generic) Electives). In this the **open electives should be of 8 credits** in a two year program (average of 4 credits each year). It is recommended that the **open electives shall be of outside the parent school** i.e. Inter school. This includes Credit Transfer from recognized online courses like SWAYAM/ MOOCS/ NPTEL/Skill oriented courses.

h. **Credit transfer from other Institutes:** Depending on the feasibility and availability a maximum of four credits can be completed by the student in any of the national or reputed institutes/organizations/companies/ industries (HOST). For this a student has to complete a minimum number of 15 interactive hours (not necessarily only teaching) with assigned faculty from host. It may be 3-4 interactive hours in a day and the necessary certificate in this regard shall be issued by host faculty. The Director of the school can fix this credit transfer mechanism with mutual consent/understanding form any host institute. After completion of minimum required interactive/teaching hours at the chosen institute the Host has to provide course completion certificate with a grade. The assessment will be made by the concerned faculty of the host and one Faculty/ Director of the concerned school (Parent) and performance grade and marks will be allotted. The same marks shall be sent to university examination section along with other marks for declaration of the results by the concerned school.

i. **Audit Courses and Additional courses**: If the student wishes to go for more number of credits, he can opt additional courses up to maximum of 10% of the total credits of the program depending on the interest of the student and other feasibilities. In general audit courses are of qualitative assessment without grades and additional credits are with grades. These additional credits shall be reflected on the Marks transcript of the student.

9. **Guidelines to Choose Open Elective Course:**

1. After taking admission in to a particular Program in the University the student has to select courses of open electives of his choice based on eligibility from other school to completely fulfil the minimum number of credits for award of degree.
2. The open electives can be selected by the student from the list available with school/prospectus.
3. He has to apply in the format to the Director of concerned schools where the particular chosen electives is being offered. The Open Elective Pro-forma should be made available to all students in the Schools.
4. After submission the applications scrutinized by the respective schools and the selected list of candidates will be displayed on the notice board with copy to the school director in which the candidate has taken admission for his basic degree.
5. It is the responsibility of the student to check the admission in to particular open elective course.
6. There will be a common time table for open electives in all the schools.
7. The assessment of open electives will be as per the norms of CBCS University guidelines and the host school offering the particular course.
8. The school should communicate the assessment results of the open electives to the Parent School.
9. Any difficulty in operating the open elective course shall be resolved by the Directors of the respective schools in consultation with concerned authority if necessary.
10. The list of open elective shall be updated by the schools from time to time based on the reviews/demand/expertise/needs of the society.

10. Examination/Evaluation Rules

The evaluation of the student will be mainly on

1. **Mid semester Assessment (MSA) and**
2. **End Semester Assessment (ESA).**
3. **The ratio of MSA and ESA is 50:50**

Passing Rules:

The MSA and ESA shall have different passing heads and Minimum passing:- 40% of passing for each subject in each head. To pass the degree program, a student will have to obtain a minimum aggregate of 40% marks (C+ and above in grade point scale) in each course.

Assessment:

Mid Semester Assessment (MSA):

MSA aims to assess values, skills and knowledge imbibed by students, internal assessment is to be done by the concerned faculty member, department, school or the centre. **MSA** will be done on a continuous basis during the semester with selected assessment components.

The components selected for MSA may be:

Tests, Quiz, Seminars, Assignments, essay, tutorials, term paper, seminar, laboratory work, field work, workshop practice, Comprehensive Viva, Attendance and any other best and innovative assessment practice approved by the School committee. Components of internal evaluation are to have a time frame for completion (by students), and concurrent and continuous evaluation (by faculty members).

The evaluation outcome shall be expressed initially by predetermined marks and latter converted by grades. Minimum Mark for passing in each Paper is 40% for Mid Semester Assessment **(MSA)**

End Semester Assessment (ESA): This is to be carried out at the end of each semester, and will aim to assess skills and knowledge acquired by the students through classroom instruction, fieldwork, laboratory work and/or workshop practice. The End Semester Assessment (ESA) is based on written examination. These examinations shall be at the end of each semester.

Integration of MSA and ESA: A student failed in MSA shall have to appear for ESA again in that particular paper. In a particular paper if a student failed in Mid Semester (MSA), he deemed to be failed in that course and he has to reappear for MSA and ESA irrespective of the marks he got in ESA. If a student passed in MSA and failed in ESA, the student needs to appear for ESA only in his next attempt and the MSA marks shall be carried.

A candidate who does not pass the examination in any course(s) shall be permitted to appear in such failed course(s) in the subsequent examinations to be held in winter/summer season. However the student has to clear the course in the prescribed maximum period for that course.

MSA marks will not change. A student cannot repeat MSA. In case s/he wants to repeat MSA, then s/he can do so only by registering the said course during the semester in which the course is conducted and up to 4 years (2 years program) as the case may be, provided the student was failed in that course. Students who have failed in a course may reappear for the ESA only twice in the subsequent period. If student fail to acquire required

Credits within four years from admission period, such student has to acquire Credits with prevailing / revised syllabus at that time. After that, such students will have to seek fresh admission as per the admission rules prevailing at that time.

A student cannot register for the third/fourth semester, if she/he fails to complete 75% credits of the total credits expected to be ordinarily completed within two semesters.

While marks will be given for all examinations, they will be converted into grades. The semester end grade sheets will have only grades and final grade sheets and transcripts shall have grade points average and total percentage of marks (up to two decimal points).

11. Assessment and Grade point average:

11.1 The system of evaluation will be as follows: Each MSA and ESA will be evaluated in terms of marks. The marks for MSA and ESA will be added together and then converted into a grade and later a grade point average.

11.2 Results will be declared for each semester.

11.3 After the completion of minimum number of credits of a program, a student will get a grade sheet with total grades earned and a grade point average.

11.4 Marks/Grade/Grade Point:

i) Table 1: Conversion of marks to grades in credit system

Marks Obtained	Grade	Grade Points
100-90	S	10
89-80	O	09
79-70	A+	08
69-60	A	07
59-55	B+	06
54-45	B	05
44-40	C+	04
39 and Less FC	FC	0 (Fail but Continue)
39 and Less (Internal)	FR	0 (Fail and Repeat the course)

ii) A student who passes the internal tests but fails in Term End Examination of a course shall be given FC grade. Student with FC grade in a course would be granted credit for that course but not the grade for that course and shall have to clear the concerned course within 1.5 year from appearing for first time in the concerned paper, provided the number of courses with FC and FR grades together is 25% or less of the courses of that semester, failing which he/she shall be disqualified for a credit and will have to opt for another credit.

iii) Student who has failed in the internal tests of a course shall be given FR grade and shall have to repeat the concerned course to qualify to appear for term end examination of that course. The grade FC and FR will be taken into consideration while calculating Semester Performance Index (SPI). It shall be replaced only when student clears the course with passing grade within 1.5 year from appearing for first time in the concerned semester.

iv) Grade points earned in each paper shall be calculated as- Grade points obtained (vide Table 1 above) X Credits for the paper.
Maximum grade points that can be earned in a semester are 200.

v) The Semester Performance Index (SPI) gives weighted performance index of a semester with reference to the credits of a course. The SPI shall be calculated as-
SPI = Total Earned Grade Pointes (as given above) for the Semester
Total Credits for the semester
11.5 The total grade point earned in each course shall be calculated as:
Grade point obtained as shown in table -1 **X** Credits for the Course
11.6 Semester Grade Point Average (SGPA): The performance of the student in a semester is indicated by number called SGPA. It shall be calculated as follows:

$$SGPA = \frac{\sum_{i=1}^{n} c_i p_i}{\sum_{i=1}^{n} c_i}$$

Where C_i = The number of Credits earned in the i^{th} course of a semester for which SGPA is to be calculated.
p_i = Grade point earned in the i^{th} course.
i = 1,2,3,4,……..n represent the number of courses in which a student is registered in the concerned semester.
That is

$$SGPA = \frac{\text{Total earned grade point for the semester}}{\text{Total credits for the semester}}$$

11.7 Final result:
The final marls after assessment will be submitted by the respective schools to the controller of Examination for finalization of the resuts. Up to date assessment of the overall performance of a student from the time of his / her first registration is obtained by calculating a number is called as Cumulative Grade Point Average (CGPA), which is weighted average of the grade points obtained in all courses registered by the student since he / she entered the department.

$$CGPA = \frac{\sum_{j=1}^{m} c_j p_j}{\sum_{j=1}^{m} c_j}$$

Where C_j = The number of Credits earned in the j^{th} course up to the semester for which CGPA is to be calculated.
p_j = Grade point earned in the j^{th} course.
j = 1, 2, 3, 4…m represent the number of courses in which a student is registered up to the semester for which the CGPA is to be calculated.

- **Final Grade: Table -2**

CGPA	Grade
09.00-10.00	S: Super
08.00-08.99	O : Outstanding
07.50-07.99	A+: Excellent
07.00-07.49	A: Very Good
06.00-06.99	B+: Good
05.00-05.99	B: Satisfactory
04.00 -04.49	C+: Pass
00.00-03.99	F: Fail

11.8 'B+' Grade is equivalent to at least 55% of the marks as per circular No. UGC- 1298/ [4619] UNI- 4 dated December 11, 1999.
11.9 "A" Grade is equivalent to first class.
11.10 If the (C) GPA is higher than the indicated upper limit in the three decimal digit, then higher final grade will be awarded (e.g. a student getting (C)GPA of 3.992 may be awarded 'C+' grade).
11.11 For grade improvement a student has to reappear for End Semester Examination (ESE) after the successful completion of the course for a minimum 20 credits in case of Science, Technology, Management and Pharmacy, 20 credits for other faculties and 12 credits in case of one year degree program. These courses will be from the parent Department (core subject). A student can appear only once for the Grade Improvement Program only after the successful completion of UG / PG Degree program and at the end of the next academic year after completion of the Degree and within two years of completion of the Degree.
11.12 The formula for CGPA will be based on Weighted Average. The final CGPA will not be printed unless a student earns minimum 100 credits, 80 credits or 64 credits, as the case may be, from the courses at UG / PG programs.
11.13 If a student failed to obtain a grade other than F in a course then such a course will not be taken into account for calculating CGPA and overall grade. In fact, all the courses in which a student has passed will be taken into account for calculating the CGPA and overall grade.

12. Norms & Procedure for Extra Credit Benefit for NSS or Participation:

The following table shows the grades along with grade point to be given to the students participating in the NSS / Sports activities:
The student should avail the only one benefit neither from NSS or Sport activities.

Maximum addition of Grade point = 0.200

Sr. No.	Event	Specification	Grade point
1	NSS Performance	2 Year regular Programme [240 hrs work + Blood donation + Camp (State / National Level)]	0.200
2	Sports Performance	Intercollegiate : I /II /III	0.150
		Inter- University : I /II /III or Participation	0.200

Structure of the course (w.e.f. 2019-20)

M.Sc. (Statistics)-I year (CBCS Pattern)

SEMESTER-I

Sr. No.	Course	Course Title	Theory/ Practical Paper	No. of Credits	Marks @ 25/Credit	Internal Component (50%)	Semester End Component (50%)	Grand Total
STATC 101	Core I	Real Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 102	Core II	Linear Algebra	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 103	Core III	Distribution Theory	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 104	Core IV	Sampling Methods	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 105	Elective Group I (04 Credit)	Statistical Computing (R Programming)	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 106		Computer Graphics	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 107		Statistics Education and Research Methodology	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 108		04 Credit Course from intra School	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE109		04 Credit Course from inter School/ NPTEL/SWAYAM/ MOOC Online certified course etc.	**L/T**	**4**	**100**	**50**	**50**	**100**
Elective (02 credit)	ELE-1 Select any one (Inter) Soft Skill I		**L/T**	**2**	**50**	**25**	**25**	**50**
STATPC 01	Core Practical I	Practical-I **(based on STATC 101 to 104)**	**P**	**3**	**75**	**--**	**75**	**75**
		Total						**625**

Note:

- STATE 105 Statistical Computing (R Programming) course (04 credits) is offered for other programme students for Intra School students.

SEMESTER-II

Sr. No.	Course	Course Title	Theory/ Practical Paper	No. of Credits	Marks @ 25/ Credit	Internal Component (50%)	Semester End Component (50%)	Grand Total
STATC 201	Core V	Probability Theory	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 202	Core VI	Regression Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 203	Core VII	Parametric Inference	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 204	Core VIII	Stochastic Processes	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 205	Elective Group II (04 Credit)	Calculus	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 206		Demography	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 207		Statistical Methods in Epidemiology and Ecology	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 208		Categorical Data Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 209		04 Credit Course from intra School	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 210		04 Credit Course from inter School/ NPTEL/SWAYAM/ MOOC Online certified course etc.	**L/T**	**4**	**100**	**50**	**50**	**100**
Elective (02 credit)	ELE-2 Select any one (Inter) Soft Skill II		**L/T**	**2**	**50**	**25**	**25**	**50**
STATPC 02	Core Practical II	Practical-I I **(based on STATC 201 to 204)**	**P**	**3**	**75**	**--**	**75**	**75**
		Total						**625**

Note:

- STATE 207 Statistical Methods in Epidemiology and Ecology course (04 credits) is offered for other programme students for Intra School students.

M.Sc. (Statistics)-II year (CBCS Pattern) (w.e.f. 2020-21)

SEMESTER-III

Sr. No.	Course	Course Title	Theory/ Practical Paper	No. of Credits	Marks@ 25/Credit	Internal Component (50%)	Semester End Component (50%)	Grand Total
STATC 301	Core IX	Industrial Statistics	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 302	Core X	Operations Research-I	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 303	Core XI	Design of Experiments	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 304	Core XII	Testing of hypotheses	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 305	Elective III (04 Credit)	Time Series Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 306		Decision Theory	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 307		Statistical Methods in Finance	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 308		Mathematical Biology	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 309		04 Credit Course from intra School	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 310		04 Credit Course from inter School/ NPTEL/SWAYAM/ MOOC Online certified course etc.	**L/T**	**4**	**100**	**50**	**50**	**100**
Elective (02 credit)	ELE-3 Select any one (Inter) Soft Skill III		**L/T**	**2**	**50**	**25**	**25**	**50**
STATPC 03	Core Practical III	Practical-III **(based on STATC 301 to 304)**	**P**	**3**	**75**	**--**	**75**	**75**
		Total						**625**

Note:

- STATC 302 Operations Research-I and STATE 307 Statistical Methods in Finance course (04 credits) is offered for Intra School students.

SEMESTER-IV

Sr. No.	Course	Course Title	Theory/ Practical Paper	No. of Credits	Marks@ 25/Credit	Internal Component (50%)	Semester End Component (50%)	Grand Total
STATC 401	Core XIII	Asymptotic Inference	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC402	Core XIV	Operations Research-II	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 403	Core XV	Multivariate Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 404	Core XVI	Reliability and Survival Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 405	Elective Group IV (04 Credit)	Data Mining Techniques	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 406		Directional Data Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 407		Actuarial Statistics	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 408		Statistical techniques in Microarray Data Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 409		Clinical Trials	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 410		04 Credit Course from intra School	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 411		04 Credit Course from inter School/ NPTEL/SWAYAM/ MOOC Online certified course etc.	**L/T**	**4**	**100**	**50**	**50**	**100**
Elective (02 credit)	ELE-4 Select any one (Inter) Soft Skill IV		**L/T**	**2**	**50**	**25**	**25**	**50**
STATPC04	Core Project	Project	**P**	**3**	**75**	**--**	**75**	**75**
		Total						**625**

Note:

- STATC 402 Operations Research-II (For STATC 402 essential prerequisite is STATC 302) and STATE 409 Clinical Trials course (04 credits) is offered for Intra School students.

List Open electives to be offered (8 credits in a four semester program):

M.A./ M.Sc. Statistics Programme						
S.N.	**Course code**	**Title of Open elective course**	**No of Credits (minimum of 2 credits)**	**Semester in which it is offered**	**Prerequisite of the student (eligibility)**	**Course instructor**
1	STATOE01	Data Analysis with Advanced Excel	02	Semester I /III (ODD)	Basics of descriptive statistics	Dr. A. A. Muley
2	STATOE02	Statistical Analysis Using R	02		Basics of statistics	Dr. A. A. Muley
3	STATOE03	Introduction to Data Mining	02	Semester II/IV (Even)	Basics of statistical techniques	Dr. A. A. Muley
4	STATOE04	Data analysis using SPSS	02		Basics of statistics	Dr. A. A. Muley

List of Core/ Elective Subjects to be offered

Core Subjects

1. Real Analysis
2. Linear Algebra
3. Distribution Theory
4. Sampling Methods
5. Practical-I (based on STATC 101 and STATC 104)
6. Probability Theory
7. Regression Analysis
8. Parametric Inference
9. Stochastic Processes
10. Practical-II (based on STATC 201 to STATC 204)
11. Industrial Statistics
12. Operations Research-I
13. Design of Experiments
14. Testing of hypotheses
15. Practical-III (based on STATC 301 to STATC 304)
16. Asymptotic Inference
17. Operations Research-II
18. Multivariate Analysis
19. Reliability and Survival Analysis
20. Project (03 credits)

Elective Subjects

Elective Group I (Any one for First Semester) (04 Credit)

1. Statistical Computing (R Programming)
2. Computer Graphics
3. Statistics Education and research Methodology

4. 04 Credit Course from Intra School

Elective Group II (Any one for Second Semester) (04 Credit)

1. Calculus
2. Demography
3. Statistical Methods in Epidemiology and Ecology
4. Categorical Data analysis
5. 04 Credit Course from other Programme within or other School

Elective Group III (Any one for Third Semester)

1. Time Series Analysis
2. Decision Theory
3. Statistical Methods in Finance
4. Mathematical Biology
5. 04 Credit Course from Intra School

Elective Group IV (Any one for Fourth Semester)

1. Data Mining Techniques
2. Directional Data Analysis
3. Actuarial Statistics
4. Statistical techniques in Microarray data analysis
5. Clinical Trials
6. 04 Credit Course from Intra School

Elective: STATE 109, 210, 310, 411 to Semester I to IV (04 Credit)

In each semester, students have to opt 02 credit courses from inter school/ NPTEL/ SWAYAM/ MOOC Online certified course (Students can opt at most 04 credits per semester and 08 credits per programme from outside the school).

Open Elective: Soft Skill-I to IV (02 Credit)

In each semester, students have to opt 02 credit courses from inter school. In this the open electives should be of 8 credits in a two year program (average of 4 credits each year). It is recommended that the open electives shall be of outside the parent school i.e. Inter school. This includes Credit Transfer from recognized online courses like SWAYAM/ MOOCS/ NPTEL/Skill oriented courses.

Open Electives for other School students: STATOE01 to STATOE 04 (02 Credit)

In each semester, students can opt 02 credit course from other programme (intra/inter) school. Students can opt any one open elective soft skill course among STATOE01 and STATOE02 at odd semesters (I/III) and among STATOE03 and STATOE0 4 at even semester (II/IV).

NOTE:

- Each semester will have Five (four core and one elective) Theory papers and each theory paper will be of 100 Marks [50 External Exam+ 50 Internal Exam (02 tests each of 15 Marks+20 Marks for Class performance/Assignments/Seminars etc.].
- Each semester student should select one elective theory paper with their respective semester's Elective Group.
- In I to IV Semester, Soft Skill course (Open Elective) will be of 50 marks [25 Internal Exam+ 25 External Exam].

- All the Practical, Soft Skill and Seminar courses are compulsory to all the students.
- Each semester is of 625 marks.
- Total marks for I sem+ II sem+ III sem + IV sem = 2500.
- Total degree is of 2500 Marks, converted in the form of 100 credits CBCS system.
- One credit is of 25 marks.
- Minimum 40% Marks are required for passing in each of the above head i.e. separate passing in External Exam and that in Internal Exam.
- Project/ Practical will be evaluated by one external examiner and one internal examiner.
- Project work will commence from 3rd semester. (i) Project carrying 75 marks and it is to be given at the beginning of Semester-III and evaluated at the end of Semester-IV.
- Project batch is of minimum 02 and maximum 05 students.
- In paper STATE105 i.e. in Statistical Computing EDA using R software will be taken.
- In STATC302 and STATC402 papers i.e. Operations Research I & II TORA software and Solver tool pack will be used for practical purpose.

Structure of the course: M.A. /M.Sc. (Statistics)-Third Semester (CBCS Pattern)

SEMESTER-III

Sr. No.	Course	Course Title	Theory/ Practical Paper	No. of Credits	Marks@ 25/Credit	Internal Component (50%)	Semester End Component (50%)	Grand Total
STATC 301	Core IX	Industrial Statistics	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 302	Core X	Operations Research-I	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 303	Core XI	Design of Experiments	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 304	Core XII	Testing of hypotheses	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE305	Elective - Gr III (04 Credit)	Time Series Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 306		Decision Theory	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 307		Statistical Methods in Finance	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 308		Mathematical Biology	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 309		04 Credit Course from intra School	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 310		04 Credit Course from inter School/ NPTEL/SWAYAM/ MOOC Online certified course etc.	**L/T**	**4**	**100**	**50**	**50**	**100**
Elective (02 credit)	ELE-3 Select any one (Intra/Inter) Soft Skill III		**L/T**	**2**	**50**	**25**	**25**	**50**
STATPC 03	Core Practical III	Practical-III **(based on STATC 301 to 304)**	**P**	**3**	**75**	**--**	**75**	**75**
		Total						**625**

Note:

- STATC 302 Operations Research I and STATE 307 Statistical Methods in Finance course (04 credits) are offered for Intra School students.

STATC 301 INDUSTRIAL STATISTICS

(Maximum no. of periods = 60)

- **Course objectives:**
- To develop scientific view to analyze the industrial data about specific perspective.
- To learn the statistical quality control techniques used in industries such as control charts, acceptance sampling plans etc.
- To learn some advanced control charts, capability indices and the concept of six-sigma.

- **Prerequisites:** Basic of data types, organization and tabulation of data, graphical representation, data transformation, distribution theory and sampling methods.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand basic of production process monitoring and apply concept of control charts on it.

CO2: Apply the acceptance and continuous sampling plans in production process.

CO3: Compute capability indices.

CO4: Know and apply the concept of weighted control charts, six sigma, ISO: 9000 series standards and Taguchi design.

Unit I: Basic concepts of process monitoring and control. Review of control charts for attributes and variable data. O. C. and ARL of control charts. CUSUM & V-masks charts. Non-parametric control charts, synthetic control chart. **(12L+3T)**

Unit II: Concepts of AQL, LTPD, AOQL average amount of inspection and ASN functions. Acceptance sampling plans for attributes inspection, single, double and sequential sampling plans and their properties. Continuous sampling plans of Dodge type and their properties. **(12L+3T)**

Unit III: Capability indices Cp, Cpk and Cpm, estimation, confidence intervals and tests of hypothesis relating to capability indices for normally distributed characteristics. **(12L+3T)**

Unit IV: The weighted control charts: Exponential Weighted Moving Average chart. Multivariate SPC: Multivariate quality control problem, description of Multivariate data, The Hotelling T^2 control chart, Multivariate EWMA control chart, regression adjustment, Latent structure methods. Quality Systems: ISO 9000 standards, concept of six sigma. Total quality management. Taguchi Design. **(12L+3T)**

REFERENCES:

1) Montgomery D.C. (1996) Introduction to Statistical Quality Control, Wiley.
2) Wetherill G.B. (1977) Sampling Inspection & Quality Control, Halsted Press.
3) Logothetis N. (1992) Managing Total Quality, Prentice Hall of India.
4) Oakland J.S. (1989) Total Quality Management; Butterworth- Heinemann.
5) Mittog H.J. and Rinne H. (1993) Statistical Methods of Quality Assurance.
6) Guenther W.C (1981) Sampling Inspection in Statistical Quality Control Charter Grifits.
7) Kotz S. (1993) Process capability indices, Chapman and Hall.
8) Abraham Bovas (1998) Quality Improvement through statistical methods
9) Birkhauser.
10) Mahajan M. (2004) Statistical Quality Control.

STATC 302 OPERATIONS RESEARCH I

(Maximum no. of periods = 60)

- **Course objectives:**
- To develop the optimization techniques that will be useful in the personal and professional life.
- To learn the mathematical formulation of complex decision-making problems and arrives at optimal or near-optimal solutions using different techniques of operations research.

- **Prerequisites:** Basic linear algebra, matrix operations, definition of set should be familiar.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand basics and formulation of linear programming problems and appreciate their limitations; solve linear programming problems using graphical method.

CO2: Apply simplex method to solve real life problems.

CO3: Solve artificial variable technique, duality theory, revised simplex method, sensitivity analysis, transportation and assignment problems.

CO4: Understand the concept of Game theory, PERT/ CPM, simulation, investment analysis with real life applications.

UNIT I: Operations research & its scope, Necessity of operations research in industry, Introductions to Linear programming problems, General linear programming problems, Mathematical Formulation of L.P.P., Basic solution, Important theorems, solution of linear programming problem, Graphical method for solution, convex set, some important theorems.

(12L+3T)

UNIT II: Theory of Simplex methods: Introduction, slack and surplus variables, some definitions and notations, Fundamental theorems of linear programming, BSF from F.S., Improved B.S.F. Unbounded solution, optimality of solutions, computational procedure of simplex method for the solution of a maximization L.P.P. **(12L+3T)**

UNIT III: Artificial variable technique. Duality, Dual simplex method, revised simplex method and sensitivity analysis. Transportation problem. Assignment problem. **(12L+3T)**

UNIT IV: Introduction, competitive game, finite and infinite game, two person zero sum game, rectangular game, solution of game, saddle point, solution of a rectangular game with saddle point. Investment analysis. Simulation. PERT-CPM, product planning control with PERT-CPM.

(12L+3T)

REFERENCES:

1) R. K. Gupta. Linear Programming, Krishna Prakashan Mandir.
2) F.S.Hillier and G.J.Liebermann,(1995) Introduction to Operations Research (6^{th} Ed.) Mc Graw Hill.
3) Kantiswaroop, P.K.Gupta and Manmohan, Operations Research, Sultan Chand & Sons, New Delhi.
4) G.Hadley, Linear Programming, Narosa publishing House, 1995.
5) G.Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.
6) H.A.Taha, Operations Research – An Introduction, Macmillan Publishing Company, Inc, New York.
7) S.S.Rao, Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
8) P. K. Gupta and D. S. Hira, Operations Research – A Introduction. S. Chand & company Ltd, New Delhi.
9) N. S. Kambo, Mathematical Programming Techniques. Affiliated East-West Press Pvt. Ltd, New Delhi.

STATC 303 DESIGN OF EXPERIMENTS

(Maximum no. of periods = 60)

- **Course objectives:**
- To learn the basic principles in the design of simple experiments.
- To learn different tests for comparing pairs of treatment means, ANCOVA, factorial experiments, fractional factorial experiments, confounding, BIBD, PBIBD with solving real life examples.
- To learn the applications of different designs in agriculture.

- **Prerequisites:** Basic designs–CRD, RBD, LSD and their analyses, missing plot techniques in RBD and LSD.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Compare the pairs of treatment means using different methods when null hypothesis in rejected in ANOVA.

CO2: Analyze the data using split plot, strip plot and general factorial experiments.

CO3: Construct fractional factorial experiments and apply confounding in real life problems.

CO4: Understand the analysis of BIBD, PBIBD, Quasi-Latin square, Youden square and cross over design and their applications in agriculture, business and industries.

UNIT I: Tests for comparing pairs of treatment means: Tukey's test, Fishers LSD test, Duncan's Multiple Range Test (DMRT), Newman- Keul's test, Dunnet test. ANCOVA: One way and Two way classification. **(12L+3T)**

Unit II: Definition and analysis of split plot design, split-split plot design and Strip plot design. General factorial experiments, factorial effects, study of 2^2, 2^3, 2^4 and 2^k factorial experiments. **(12L+3T)**

Unit III: Study of 3^2, 3^3 designs : Contrasts for linear and quadratic effects, statistical analysis of 3^k design. Fractional factorial experiments. Resolution III, IV and V of a design aberration of a design. Confounding in factorial experiments, complete and partial confounding. Response surface method, Taguchi's design. **(12L+3T)**

Unit IV: Elementary parametric relations and analysis of BIBD. Definitions and parametric relations of PBIBD. Definition and analysis of Quasi-Latin square designs, Youden square design. Cross-over designs. **(12L+3T)**

REFERENCES:

1) Alok Dey (1986) Theory of Block Designs, Wiley Eastern.
2) Das, M.N. and Giri, N. (1979) Design and Analysis of Experiments, Wiley.
3) Joshi, D. D. (1987) Linear Estimation and Design of Experiments, John Wiley.
4) Montgomery, D.C. (2005) Design & Analysis of Experiments, Wiley.
5) Chakrabarti M. C.(1962) Mathematics of Design and Analysis of Experiments, Asia Pub. Hs.
6) Cochran W.G. & Cox D.R.(1957) Experimental Designs, 2nd Ed., JohnWiley.
7) Dean A. M. & Voss D. (1999) Design and Analysis of Experiments, Springer.
8) Dey A. & Mukerjee R. (1999) Fractional Factorial Plans, John Wiley.
9) Dey A. (1986) Theory of Block Designs, Wiley Eastern.
10) John J.A. & Quenouille M.H. (1977) Experiments: Design and Analysis, Charles & Griffin.
11) Kempthorne, O. (1976) Design and Analysis of Experiments, John Wiley.

12) Khuri A.I. & Cornell J.A. (1996) Response Surface Designs and Analysis. 2nd Ed.,Marcel Dekker.
13) Raghavarao D. (1971) Construction and Combinatorial Problems in Design of Experiments, John Wiley.

STATC 304 TESTING OF HYPOTHESES

(Maximum no of periods: 60)

- **Course objectives:**
- To learn the development of null and alternative hypotheses.
- To learn types of errors, non-parametric tests.
- To perform Test of Hypothesis as well as obtain MP, UMP tests.

- **Prerequisites:** Basics of data types, distribution of data, statistical inference etc.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Formulate null and alternative hypotheses and apply small, large sample and non-parametric tests in real life problems.

CO2: Compute probabilities of types of error, MP tests and MLR property.

CO3: Understand UMP and UMPU test with their applications.

CO4: Obtain asymptotic confidence interval of a parameter and its relation with testing of hypothesis problem.

UNIT I: Problem of testing of hypothesis: Simple and Composite hypotheses. Small sample tests: t, F and Chi-square test, goodness of fit test based on Chi-square, application to contingency tables, large sample tests. Nonparametric tests: Sign test, run test, Median test, rank test, Wilcoxon signed rank test, Mann Whitney test, Kolmogorov Smirov test, Kruskal-Wallies test.

(12L+3T)

UNIT II: Types of errors, size and power of the test. Power function of a test. Randomized and non-randomized tests. Most powerful test, Neyman-Pearson Lemma and its applications. Generalized Neyman Pearson Lemma. Monotone likelihood ratio (MLR) property.

(12L+3T)

UNIT III: Existence of UMP tests for one-sided alternatives. UMP tests for two sided alternatives, their existence and non-existence. Unbiased test, UMPU tests and their existence in the case of exponential families. (Statements of the theorems only), Similar tests, test with Neyman structure, locally most powerful tests. **(12L+3T)**

UNIT IV: Problem of confidence intervals, relation with testing of hypotheses problem, UMA and UMAU confidence intervals, shortest length confidence intervals. Likelihood ratio test.

(12L+3T)

REFERENCE:

1) Kale B.K. (1999): A first Course on Parametric Inference-Narosa
2) Rohatgi V.K.(1988): Introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd. New Delhi. Student Edition.
3) Dudewicz E.J. & Mishra S.N.(1988): Modern Mathematical Statistics, Wiley Series
4) Lehman E.L. (1987): Theory of Testing of Hypotheses. Student Edition.
5) Ferguson T.S. (1967): Mathematical Statistics*:* A decision Theoretical Approach*.* Academic Press.

6) Zacks S.(1971): Theory of Statistics Inference- John Wiley and Sons, New York.

STATE 305 TIME SERIES ANALYSIS

(Maximum no. of periods = 60)

- **Course objectives:**
- To learn and develop scientific view to understand the time series data and its analysis.
- To learn stationary and non-stationary, and seasonal and non-seasonal time series models.
- Learn to estimate model parameters and compare different models developed for the same dataset in terms of their estimation and prediction accuracy.

- **Prerequisites:** Basic of data types, organization and tabulation of data, regression analysis etc.

- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand the concept of time series with its components and able to compute ACVF and ACF.

CO2: Remove trend and seasonality using different methods to convert the time series into stationary.

CO3: Apply auto regressive, moving average, ARMA, ARIMA models, Box-Jenkins approach to forecast time-series data empirically.

CO4: Check and validate models with its residual analysis and diagnostic checking.

.

UNIT I: Time-series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties. **(12L+3T)**

UNIT II: Exploratory Time Series Analysis: Tests for trend and seasonally, Exponential and Moving average smoothing. Holt winters smoothing. Forecasting based on smoothing, adaptive smoothing. **(12L+3T)**

UNIT III: Stationary processes: (i) moving average (MA), (ii) Auto Regressive (AR), (iii) ARMA and (iv) AR integrated MA (ARIMA) models, Box-Jenkins models. Discussion, (without proof) of estimation of mean, auto covariance and auto correlation functions under large sample theory. **(12L+3T)**

UNIT IV: Choice of AR and MA periods, Estimation of ARIMA models parameters. Forecasting, Residual analysis and diagnostic checking. Spectral analysis of weakly stationary process, Periodogram and Correlogram analysis. Spectral Decomposition of weakly AR process and representations as one sided MA process- necessary and sufficient conditions. **(12L+3T)**

REFERENCES:

1) Anderson, T. W (1971) The Statistical Analysis of Time Series, Wiley, N.Y.
2) Box, G.E.P. and Jenkins, G.M. (1976) Time Series Analysis-Forecasting and Control, Hodlen-day, San Francisco.
3) Kendall, Sir Maurice and Ord. J. K. (1990) Time Series, 3rd Ed., Edward Arnold.
4) Montgomery, D. C. and Johnson, L. A. (1977) Forecasting and Time Series Analysis, McGraw Hill.
5) Brockwell P.J. and Davis R.A. (1991) Time Series: Theory and Methods, 2nd Ed.,Springer-Verlag.
6) Fuller W.A. (1976) Introduction to Statistical time series, John Wiley N.Y.
7) Priestley M.B. (1981) Spectral analysis and time Series Griffin London.
8) Kendall M.G. And Stuart A. (1996) The advanced theory of Statistics, Vol. 3, Charles Griffin London.
9) Bloomfield P (1976) Fourier analysis of Time series – an introduction, Wiley.
10) Granger C.W. J and Hatanks (1964) Spectral analysis of economic Time Series, Princeton University Press N.J.

11) Koopmens C.R. (1973) The Spectral analysis of time series, Academic presses.
12) Nelson C.R. (1973) Applied Time Series for managerial forecasting, Holden –day.
13) Findley D.F.(1981) Applied Time Series analysis, Academic Press.
14) Wethirll G.B. (1986) Regression analysis with applications, Chapman Hall.

STATE 306 DECISION THEORY

(Maximum no. of periods = 60)

- **Course objectives:** To learn various decision rules theories and its applications of decision making as individuals, in groups, and in organizations.

- **Prerequisites:** Basics of data types, distribution theory etc**.**

- **Course Outcomes:**
  After completion of the course students will able to:

CO1: Understand decision problem, loss function, risk function and decision rules.

CO2: Understand the concept of admissibility and completeness.

CO3: Implement nonparametric statistical tests.

CO4: Apply two sample problems on real life examples.

Unit I: Decision problem, loss function, risk function, randomized and non-randomized decision rule. Decision principles (Conditional Bayes, Frequentist). Testing and estimation problem as decision problems. Optimal decision rule. **(12L+3T)**

Unit II: Concept of admissibility and completeness, Bayes rules, minimax decision rule. Admissibility of Bayes rules. Existence of Bayes decision rule. **(12L+3T)**

Unit III: Definition of non-parametric test, advantages and disadvantages of nonparametric tests. Single sample problems. (i) Test of randomness (ii) Tests of goodness of fit: Empirical distribution function. Kolmogorov-Smirnov test, comparison of Chi-squareand KS test. (iii) Problem of location: Sign test, Wilcoxon's signed rank test, Wilcoxon paired sample signed rank test. **(12L+3T)**

Unit IV: Two Sample Problems: Different types of alternative, sign test, Wilcoxon two sample rank sum test, Wald-Wolfiwitz run test, Mann-Whitney-Wilcoxon test, median test. K-S two sample test. One sample U statistic, Kernel and symmetric Kernel, variance of U statistic, two sample U statistics, linear rank statistics and their distribution properties under null hypothesis. **(12L+3T)**

REFERENCES:

1) Ferguson T. S. (1967) Mathematical Statistics, Academic Press, New York.
2) Fraser, D.A.J. (1957) Non-parametric methods in Statistics, John Wiley.
3) Gibben J.D.(1992) Non Parametric Statistical inference, Marcel Dekker, Inc., New York.
4) Goon A.M., Gupta M.K., Dasgupta : An Outline of Statistical Inference. The World Press Pvt. Ltd.
5) Berger, J.O. (1980) Statistical Decision Theory: Foundations, Concepts and Methods, Springer-Verlag.
6) Berger, J.O. (1985) Statistical Design Theory and Bayesian Analysis, 2nd ed., Springer-Verlag.
7) Gupta S. S. and Huang, D. (1981) Multiple Statistical Decision Theory, Springer-Verlag, New York.

STATE 307 STATISTICAL METHODS IN FINANCE

(Maximum no of periods: 60)

- **Course objectives:** To learn and develop an analytic approach to deal with financial data.

- **Prerequisites:** Basics of stochastic processes**.**

- **Course Outcomes**:
  After completion of the course students will able to:

CO1: Understand the concept of returns, efficient market hypothesis and compounding.
CO2: Understand the concept of one risky and two risky assets, portfolio theory.
CO3: Apply the concept capital asset pricing model.
CO4: Understand option pricing, Value at risk, the concept of re-sampling.

UNIT I: Introduction and behaviour of Returns, Origins of Random Walk Hypothesis, Efficient Market Hypothesis (EMH). Discrete and Continuous compounding. **(12L+3T)**

UNIT II: Trading Off Expected Return and Risk, One Risky Asset and Two Risky Assets. Combining Two Risky Assets with a Risk-Free Asset. Risk-Efficient Portfolios with N Risky Assets. **(12L+3T)**

UNIT III: Introduction to Capital Asset Pricing Model(CAPM). Capital Market Line(CML). Betas and the Security Market Line, Security Characteristic Line. Estimation of Beta and Testing CAPM. **(12L+3T)**

UNIT IV: Introduction of Option Pricing, Call Options. The law of One Price. Time value of Money and Present Value, Pricing Calls. Martingales. Introduction of Fixed Income Securities. Zero-Coupon Bonds, Yield to Maturity, Term Structure. Introduction of Resampling, Resampling and efficient Portfolios. Need for Risk Management, Value-At-Risk(VaR) with one asset, VaR for a Portfolio Assets. **(12L+3T)**

REFERENCES:

1) David Ruppert,(2004) Statistics and Finance –An Introduction, Springer Texts in Statistics.
2) R. A. Johnson and D. W. Wichern,(2007) Applied Multivariate Statistical Analysis, 6th edition, Prentice Hall, New Jersey.

STATE 308 MATHEMATICAL BIOLOGY

(Maximum no. of periods = 60)

- **Course objectives:**
- To learn the theory of mathematical modeling and its applications in the analysis of biological systems including populations of molecules, cells and organisms.
- To develop skills in mathematical modeling.

- **Prerequisites:** Basic of data types, stochastic processes etc.
- **Course Outcomes:**
  After completion of the course students will able to:

CO1: Understand linearization of dynamical systems with various dimensions.
CO2: Understand translation properties and various criterions.
CO3: Describe single and multi-species population growth models.
CO4: Apply the concept of deterministic and stochastic models on simple and general epidemics.

Unit I: Linearization of dynamical systems (two, three, and higher dimensions), Stability theory: (a) asymptotic stability (Hartman's theorem), (b) Global stability (Liapunov's direct method).
(12L+3T)

Unit II: Translation property, limit sets, attractors, periodic orbits, limit cycles and separatrix, Bendixon criterion, Dulac criterion, Poincare-Bendixon theorem, Bifurcation: saddle-node, transcritical, pitchfork, Hopf. **(12L+3T)**

Unit III: Single, and multispecies population growth models, predator-prey models, competition models, models on mutualism, food chain models, time delay models, phytoplankton-zooplankton models. Fick's law, Turing pattern, diffusion driven instability, population dynamics models with self and cross diffusion. **(12L+3T)**

Unit IV: Deterministic, and stochastic models on simple epidemics, general epidemics, pure birth-death process, simple models on spatial spread of epidemics, recurrent epidemics models. Models on malaria, HIV, AIDS, Dengue. Basic concepts on eco-epidemiological systems. **(12L+3T)**

REFERENCES:

1. D. N. Jordan and P. Smith (1998): Nonlinear ordinary equations-an introduction to dynamical systems (3rd ed)
2. L. Perko (1991): Differential equations and dynamical systems.
3. H. I. Freedman (1990): Deterministic mathematical models in population ecology (pure and applied mathematics)
4. Mark Kot (2001): Elements of mathematical ecology.
5. J. D. Murray (1990): Mathematical biology.
6. Eric Renshaw (1990): Modelling biological population in space and time.
7. Leah Edelestin-Keshet (2005): mathematical models in biology.
8. N. T. J. Bailey (1975): The mathematical theory of infectious diseases and its applications.
9. Roy M Anderson and Robert M May (1991): Infectious diseases of humans: dynamics and control.
10. Horst Malchow, Sergei V Petrovoski, and Ezio Venturino (2008): Spatiotemporal patterns in ecology and epidemiology: theory, models and simulations.

Core Practical-III STATPC03 Practical-III (Based on STATC 301 to 304)

- **Course Outcomes:**

After completion of the practical students will able to:
CO1: Draw controls charts and apply acceptance sampling plans in industry point of view.
CO2: Apply operations research techniques to solve real life problems.
CO3: Apply different designs in real life situations.
CO4: Obtain MP and UMP test.

Structure of the course: M.A. / M.Sc. (Statistics)-Fourth Semester (CBCS Pattern)

SEMESTER-IV

Sr. No.	Course	Course Title	Theory/ Practical Paper	No. of Credits	Marks@ 25/Credit	Internal Component (50%)	Semester End Component (50%)	Grand Total
STATC 401	Core XIII	Asymptotic Inference	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 402	Core XIV	Operations Research-II	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 403	Core XV	Multivariate Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATC 404	Core XVI	Reliability and Survival Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 405	Elective (A/B/C/D/ E/F/G) - Gr IV (04 Credit)	Data Mining Techniques	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 406		Directional Data Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 407		Actuarial Statistics	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 408		Statistical techniques in Microarray Data Analysis	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 409		Clinical Trials	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 410		04 Credit Course from intra School	**L/T**	**4**	**100**	**50**	**50**	**100**
STATE 411		04 Credit Course from inter School/ NPTEL/SWAYAM/ MOOC Online certified course etc.	**L/T**	**4**	**100**	**50**	**50**	**100**
Elective (02 credit)	ELE-4 Select any one (Intra/Inter) Soft Skill IV		**L/T**	**2**	**50**	**25**	**25**	**50**
STATPC04	Core Project	Project	**P**	**3**	**75**	**--**	**75**	**75**
		Total						**625**

Note:

- STATC 402 Operations Research-II (For STATC 402 essential prerequisite is STATC 302) and STATE 409 Clinical Trials (04 credits) is offered for Intra School students.

STATC 401 ASYMPTOTIC INFERENCE

(Maximum no of periods: 60)

- **Course objectives:**
- To develop generalization aspect of inferential theory.
- To get familiarise with the theories and methods of asymptotic inference.

- **Prerequisites:** Basics of statistical inference, testing of hypothesis. The knowledge about construction of point and interval estimators, and hypothesis testing; and the evaluation of these estimators and tests.

- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand the concept of consistency and asymptotic normality.

CO2: Understand method of moments and percentiles, maximum likelihood to find consistent estimator and Cramer Huzurbazar theorem.

CO3: Apply likelihood ratio tests, Wald, Score and Bartlett's test in real life situations.

CO4: Compare various tests through relative asymptotic efficiency.

UNIT I: Consistent estimator, joint and marginal consistency, invariance property of consistency. Consistency , BAN and asymptotic normality (CAN) of real and vector parameters. Invariance of consistency under continuous transformation. Invariance of CAN estimators under differentiable transformations, generation of CAN estimators using central limit theorem.

(12L+3T)

UNIT II: Method of moments and percentiles, method of maximum likelihood, Special cases such as exponential class of densities and multinomial distribution, Cramer-Huzurbazar theorem, method of scoring. **(12L+3T)**

UNIT III: Likelihood ratio tests, asymptotic distribution of log likelihood ratio, Wald Test, Score Test, Bartlett's test for homogeneity of variances. **(12L+3T)**

UNIT IV: Pearson's chi-square test and LR test. Asymptotic comparison of tests. Asymptotic Relative Efficiency (Pitman's), asymptotic normality of posterior distributions. **(12L+3T)**

REFERENCES:

1) Kale B.K. (2005) A First Course on Parametric Inference, Second Edition, Narosa.
2) Cramer, H.(1974) Mathematical Methods in Statistics, Princeton Univ. Press.
3) Rao,C.R.(1995) Linear Statistical Inference and its Applications,Wiley Eastern Ltd.
4) Silvey, S. D.(1975) Statistical Inference, Chapman- Hall.
5) Wilks, S.S.(1962) Mathematical Statistics, John Wiley.
6) Ferguson, T.S. (1996) A Course in Large Sample Theory, Chapman and Hall.
7) Srivastava, M. K., Khan, A. H., & Srivastava, N. (2014). Statistical inference: theory of estimation. PHI Learning Pvt. Ltd.

STATC 402 OPERATIONS RESEARCH-II

(Maximum no of periods: 60)

- **Course objectives:** To learn advanced methods in operations research course that are used in the systems approach to Engineering and Management, so as to provide them with the requisite tools for the mathematical representation of decision-making problems, in particular emphasizing the roles of uncertainty and risk.
- **Prerequisites:** Basic knowledge of linear algebra, distribution theory and linear programming.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Solve real life problem using integer programming.

CO2: Use dynamic programming in multistage solution problem.

CO3: Deal with inventories of various goods with and without shortages.

CO4: Understand and deal with queuing theory, Non-linear (concave) real life optimization problems, Quadratic programming problems.

UNIT I: Integer Linear Programming Problem (ILPP): The concept of cutting plane, Gomory's method of cutting plane for all ILPP and mixed ILPP, Branch and Bound method. **(12L+3T)**

UNIT II: The Recursive equation approach and characteristic of Dynamic programming, Dynamic programming algorithm, Deterministic processes, Non-sequential discrete optimization-allocation problems. **(12L+3T)**

UNIT III: Inventory models: Inventory problems and their analytical structure.EOQ, deterministic models of inventory control. Inventory (S,s) policy periodic review models with stochastic demand. Probabilistic re-order point, lot size inventory system. **(12L+3T)**

UNIT IV: Basic characteristics of queuing system, different performance measures, steady state solution of Markovian queuing models: M/M/1, M/M/1 with limited waiting space M/M/C, M/M/C with limited waiting space. Non-linear programming, Quadratic programming: Kuhn-Tucker conditions of optimality, methods due to Beale, Wolfe. **(12L+3T)**

REFERENCES:

1) R. K. Gupta "Linear Programming",Krishna Prakashan Mandir.
2) F.S.Hillier and G.J.Liebermann,(1995) Introduction to Operations Research (6th Ed.) Mc Graw Hill.
3) Kantiswaroop, P.K.Gupta and Manmohan, Operations Research, Sultan Chand & Sons, New Delhi.
4) G.Hadley, Linear Programming, Narosa publishing House, 1995.
5) G.Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.
6) H.A.Taha, Operations Research - An Introduction, Macmillan Publishing Company, Inc, New York.
7) S.S.Rao, Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
8) P. K. Gupta and D. S. Hira, Operations Research – A Introduction. S. Chand & company Ltd, New Delhi.
9) N. S. Kambo, Mathematical Programming Techniques. Affiliated East-West Press Pvt. Ltd, New Delhi.

STATC 403 MULTIVARIATE ANALYSIS

(Maximum no. of periods: 60)

- **Course objectives:**
- To learn and develop scientific view to deal with multidimensional datasets and its uses in the analysis of research data.
- To understand the extensions of univariate techniques to multivariate frameworks and learn to apply dimension reduction techniques used in the data analysis.
- **Prerequisites:** Basic of data types, Linear algebra, univariate statistical inference, probability distribution, estimation procedures and statistical hypotheses testing.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand multivariate normal distribution and their real life applications.

CO2: Understand Wishart distribution, Hotelling T^2 and Mahalanobis D^2 statistic.

CO3: Implement dimension reduction techniques using software on real life problems.

CO4: Demonstrate knowledge and understanding of the basic ideas behind discriminant and clustering analysis techniques with applications.

UNIT I: Multivariate normal distribution, marginal and conditional distribution, singular and non-singular normal distribution, Characteristic function, Maximum likelihood estimators of the mean vector and covariance matrix. **(12L+3T)**

UNIT II: Wishart Distribution: Wishart matrix- its distribution and properties, Distribution of sample generalized variance. Hotelling's T^2 statistics and its distribution. Application T^2 Statistics and its relationship with Mahalanobis D^2 Statistics. **(12L+3T)**

UNIT III: Dimension reduction techniques: Principal components analysis, factor analysis. Canonical variables and canonical correlation–definition, use, estimation and computation. Multivariate Analysis of Variance (MANOVA) of one and two–way classified data. **(12L+3T)**

UNIT IV: Cluster analysis. Classification and discrimination procedures for discrimination between two multivariate normal populations–sample discriminant function, probabilities of misclassification and their estimation. **(12L+3T)**

REFERENCES:

1) Anderson T.W. (1983) An Introduction to Multivariate Statistical Analysis, 2nd Ed. Wiley.
2) Giri N.C. (1977) Multivariate Statistical Inference, Academic press.
3) Kshirsagar A.M. (1972) Multivariate Analysis, Marcel Dekker.
4) Morrison D.F. (1976) Mathematical Statistics Methods, 2nd Ed Mc-Graw Hill.
5) Rao.C.R.(2002) Linear Statistical Inference and Its Application 2nd Ed. Wiley.
6) Seber G. A. F. (1984) Multivariate observations Wiley.
7) Sharma S. (1996) Applied multivariate techniques Wiley.
8) Srivastava S. and Khatri C.G. (1979) An introduction to Multivariate Statistics, North Holland.
9)Johnson and Wichern (1992) Applied multivariate Statistical Analysis, Prentice Hall 3rd Ed.
10) Roy S.N. (1987) Some Aspects of Multivariate Analysis John Wiley.
11) Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, J. Wiley.
12) Bhuyan K.C. (2005) Multivariate Analysis and its application, New Central book age,

Ltd. Kolkatta.

STATC 404 RELIABILITY AND SURVIVAL ANALYSIS

(Maximum no of periods: 60)

- **Course objectives:**
- To learn the reliability theory and analysis of survival data.
- To distinguish censored and uncensored data.
- To visualize and communicate time-to-event data, to fit and interpret failure time model.

- **Prerequisites:** Basic of data types, organization of data, Distribution theory.

- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand the elements of reliability, hazard function and its applications.

CO2: Understand the concept of censoring, life distributions and ageing classes.

CO3: Estimate nonparametric survival function of the data.

CO4: Explain test of exponentiality against nonparametric classes, two sample problems.

UNIT I: Elements of Reliability, definition and relationship between survival function, hazard function, distribution with IFR and DFR, series, parallel, k out of n: G, coherent systems. Life testing experiments, stress–strength reliability and its estimation. **(12L+3T)**

UNIT II: Basic concepts of Time, Order and Random Censoring. Life distributions - Exponential Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference Point estimation, Confidence Intervals, mean residual life and their elementary properties. **(12L+3T)**

UNIT III: Ageing classes - IFR, IFRA, NBU, NBUE, HNBUE and their duals, Bathtub Failure rate. Estimation of survival function - Actuarial Estimator, Kaplan – Meier Estimator, Estimation under the assumption of IFR/DFR. **(12L+3T)**

UNIT IV: Tests of exponentiality against non-parametric classes - Total time on test, Deshpande test. Two sample problem - Gehan Test, Log rank test. Mantel – Haenszel Test, Tarone-Ware tests. Semi-parametric regression for failure rate, Cox's proportional hazards model with one and several covariates. **(12L+3T)**

REFERENCES:

1) Cox, D.R. and Oakes, D. (1984) Analysis of Survival Data, Chapman and Hall, New York.
2) Gross A.J. and Clark, V. A. (1975) Survival Distributions: Reliability Applications in the Biomedical Sciences, John Wiley and Sons.
3) Elandt - Johnson, R.E. Johnson N.L. (1980) Survival models and Data Analysis, John Wiley.
4) Miller, R.G. (1981) Survival Analysis, Wiley.
5) Zacks, S. Reliability.

STATE 405 DATA MINING TECHNIQUES

(Maximum no of periods: 60)

- **Course objectives:**
- To understand the concept of data Mining for enterprise data management and as a cutting edge technology tool.
- To enable to identify data sources, processing and imparting knowledge tools to analyze sets of data to gain useful business understanding.
- **Prerequisites:** Basics of data types, organization and tabulation of data, multivariate analysis etc.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Organize and prepare the data needed for data mining using pre-processing techniques.

CO2: Understand unsupervised learning techniques for univariate and multivariate data.

CO3: Understand supervised learning techniques for moderate to high dimensional spaces.

CO4: Apply classification methods to real life problems in various fields.

UNIT I: Introduction to data mining, Data pre-processing, Exploration visualization Techniques, Basic data mining tasks, Introduction to databases, including simple relational databases, data warehouses and introduction to online analytical data processing. **(12L+3T)**

UNIT II: Unsupervised learning from univariate and multivariate data, Association rules and prediction, data attributes, applications to electronic commerce, Dimension reduction and feature selection. Clustering methods from both statistical and data mining viewpoints, kernel method. **(12L+3T)**

UNIT III: Supervised learning from moderate to high dimensional input spaces, generative/ discriminative learning, parametric/ nonparametric learning, artificial neural networks and extensions of regression models and support vector machines. **(12L+3T)**

UNIT IV: Classification Basics, Review of classification methods from multivariate analysis, classification and decision trees. Performance metrics, assessment performance metrics for Prediction and Classification; Applications of data mining, autonomous navigation, bioinformatics, speech recognition, and text and web data processing. **(12L+3T)**

REFERENCES:

1) Berson, A. and Smith, S.J. (1997) Data Warehousing, Data Mining, and OLAP, McGraw-Hill.
2) Breiman, L., Friedman, J.H., Olshen, R.A. and Stone, C.J. (1984) Classification and Regression Trees, Wadsworth and Brooks/Cole.
3) Han,J. and Kamber.M. (2000) Data Mining; Concepts and Techniques, Morgan Kaufmann.
4) Mitchell, T.M. (1997) Machine Learning, McGraw-Hill.
5) Ripley, B.D. (1996) Pattern Recognition and Neural Networks, Cambridge University Press.

STATE 406 DIRECTIONAL DATA ANALYSIS

(Maximum no of periods: 60)

- **Course objectives:** To learn understanding of data analysis using statistics computational tools on problems of applied nature.
- **Prerequisites:** Basic of data types, organization and tabulation of data, distribution theory and methods of estimation etc.

- **Course Outcomes:**

After completion of the course students will able to:

CO1: Visualize the large data-set effectively.
CO2: Understand circular models and concepts of some advanced distributions.
CO3: Understand the methods of estimation.
CO4: Apply nonparametric methods to real life problems.

UNIT I: Graphical representation of data, Frequency distribution, Measures of location, circular variance and concentration, Correction for mean grouping, Measures of skewness and kurtosis. **(12L+3T)**

UNIT II: Circular models, distribution theory, independence, convolution, moments, distributions of an arc, mixtures, lattice distributions, wrapped normal, Cauchy, Poisson distributions, Von Mises, Fisher distribution characteristics functions, Polar distributions, isotropic random walk on the circle. **(12L+3T)**

UNIT III: Point estimation, Cramer Rao type bound, sufficiency, Methods of estimation. Testing hypothesis from parametric models. Neyman-Pearson and likelihood ratio principles **(12L+3T)**

UNIT IV: Non-parametric methods: Tests for randomness, goodness of fit, Rayleigh's test. Durand and Greenwood's test, Range test, Kuper's test, Watson's test, Uniform score tests, Runs test, Rank sum test, Test for dispersion. **(12L+3T)**

REFERENCES:

1) Mardia K.V. (1972): Statistics of Directional data, Academic Press.
2) Batschelet E. (1981): Circular Statistics in Biology, Academic Press.
3) Watson G. S. (1983): Statistics on Spheres, Wiley.

STATE 407 ACTUARIAL STATISTICS

(Maximum no of periods: 60)

- **Course objectives:**
- To learn the life tables used in insurance products.
- To learn the concept of interest, different life insurance products, life annuities, net premiums.
- To motivate students to prepare for exams required for employment in the actuarial science profession.
- **Prerequisites:** Understandings of distributions theory.

- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand the utility theory, insurance products and life tables.
CO2: Understand the concept of interest.
CO3: Understand the concept of life insurance and the existing insurance products of different insurance company.

CO4: Know life annuities, net premium and net premium reserves.

UNIT I: Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality. Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. **(12L+3T)**

UNIT II: Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. **(12L+3T)**

UNIT III: Life insurance: Insurance payable at the moment's of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance. **(12L+3T)**

UNIT IV: Life annuities: Continuous life annuities, discrete life annuities, life annuities with monthly payments. Net premiums: Continuous and discrete premiums, true monthly payment Premiums and some practical considerations. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums. **(12L+3T)**

REFERENCES:

1) N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones and C. J. Nesbitt, Actuarial Mathematics, Society of Actuaries, Itasca, IIIinois, U. S. A. 2nd d.(1997)
2) Deshmukh S.R. (2009) An Introduction to Actuarial Statistics Using R, Uni. Press.
3) Spurgeon E. T. (1972) Life Contingencies, Cambridge University Press.
4) Neill, A. (1977) Life Contingencies, Heinemann.

STATE 408 STATISTICAL TECHNIQUES IN MICROARRAY DATA ANALYSIS

(Maximum no of periods: 60)

- **Course objectives:** To learn and develop problem formulations that may be answered by microarray analysis.
- **Prerequisites:** Basic of statistical inference, parametric-non parametric tests, multivariate analysis and a very basic knowledge of R statistical language.
- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand and setup for microarray experiments and quantification.

CO2: Understand statistical inference procedures in comparative experiments for single channel microarray data.

CO3: Formulate multiple hypotheses testing problems that can be addressed by microarray data analysis.

CO4: Apply hierarchical cluster analysis in microarray data.

Unit I: Background of Microarrays and Normalization techniques Introduction to Biology relevant to microarray experiment. Microarray experimental set up and quantification of information available from microarray experiments. Data cleaning, transformation of data. Between array & within array normalization, in particular quantile and LOWESS normalization, stage wise normalization. Concordance coefficient and its role. **(12L + 3T)**

Unit II: Statistical Inference procedures in comparative experiments for single channel microarray data. Application of two sample t –test. Tests for validating assumptions of two sample t-test. Application of Welch test and Wilcoxon rank sum test. Inference procedures for two channel microarray data. Application of paired t –test. Tests for validating assumptions of paired ttest. Application of Wilcoxon signed rank test. Inference procedures for comparing more than two types of mRNA samples in single channel or two channel microarray experiments. Application of one way ANOVA F test, one way ANOVA Welch F test, Kruskal-Wallis test, pairwise t-test, pairwise Welch test and pairwise Wilcoxon rank sum test. Strip charts and its role to decide the profile of differentially expressed genes. **(12L + 3T)**

Unit III: Multiple hypotheses testing problem and Principal component analysis, Multiple hypotheses testing problem. Adjustments for multiple hypotheses testing, adjusted p-values. False discovery rate. Principal component analysis for microarray data, scree plot, plot of scores to rectangular matrix and the concept of ballot. Its application to microarray data analysis. **(12L + 3T)**

Unit IV: Hierarchical cluster analysis of microarray data to identify groups of genes and outlying genes K - means cluster analysis of microarray data to identify groups of genes. Application of logistic regression for microarray data. Concept of AIC and BIC and its role to identify marker genes. **(12L + 3T)**

REFERENCES:

1) Amartunga D. and Cabrera J. (2004). Exploration and Analysis of DNA Microarray and Protein Array Data. Wiley.
2) Deshmukh S.R. and Purohit S.G. (2007). Microarray Data: Statistical Analysis Using R, Narosa.
3) Draghici, S. (2003). Data Analysis Tools for DNA Microarrays, Chapman and Hall/CRC.
4) Dov, S. (2003). Microarray Bioinformatics, Cambridge University Press.
5) McLachlan, G.J., Do, K.A. and Ambroise, C. (2004). Analyzing Microarray Gene Expression Data, Wiley.
6) Simon, R.M ,Korn, E.L., McShane, L.M. ,Radmacher, M.D. Wright, G.W. and Zhao, y. (2003). Design and Analysis of DNA Microarray Investigations. Springer.
7) Speed, T. (2003). Statistical Analysis of Gene Expression Microarray Data, Chapman and Hall/CRC.

STATE 409 CLINICAL TRIALS

(Maximum no of periods: 60)

- **Course objectives:**
- To learn and develop scientific view to study the statistical challenges of clinical comparison of two or more treatments in human subjects.
- To Aware of the use of the cross-over design and its limitations.

- **Prerequisites:** Basics of data types, data collection and design of experiment.

- **Course Outcomes:**

After completion of the course students will able to:

CO1: Understand need and ethics of clinical trials.

CO2: Apply various designs of clinical trials to the data.

CO3: Describe optimal cross-over designs experiment with a continuous normally distributed outcome.

CO4: Understand designs based on clinical endpoints, drug interaction study.

Unit I: Introduction to clinical trials: need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multicenter trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice. Bioavailability, pharmacokinetics and pharmaco-dynamics, two-compartment model. **(12L+3T)**

Unit II: Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials. Design and monitoring of Phase III trials with sequential stopping, design of bio-equivalence trials. Inference for 2x2 crossover design: Classical methods of interval. **(12L+3T)**

Unit III: Power and sample size determination, multiplicative (or log-transformed) model, ML method of estimation, assessment of inter and intra subject variabilities, detection of outlying subjects. Optimal crossover designs: Balaam's design, Two sequence dual design. Optimal four period designs. Assessment of bioequivalence for more than two drugs, Williams design. **(12L+3T)**

Unit IV: Designs based on clinical endpoints: Weighted least squares method, log-linear models, generalized estimating equations. Drug interaction study, dose proportionality study, steady state analysis. Interim analysis and group sequential tests, alpha spending functions. Analysis of categorical data. **(12L+3T)**

Books Recommended

1. Chow S.C. and Liu J.P.(2009). Design and Analysis of Bioavailability and bioequivalence. 3rd Edn. CRC Press.
2. Chow S.C. and Liu J.P. (2004). Design and Analysis of Clinical Trials. 2nd Edn. Marcel Dekkar.
3. Fleiss J. L.(1989). The Design and Analysis of Clinical Experiments. Wiley.
4. Friedman L. M.Furburg C. Demets D. L.(1998). Fundamentals of Clinical Trials, Springer.
5. Jennison .C. and Turnbull B. W. (1999). Group Sequential Methods with Applications to Clinical Trails, CRC Press.
6. Marubeni .E. and Valsecchi M. G. (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley.

Core Project STATPC04

(03 Credit Course)

- **Course Outcomes:**

After completion of the project students will able to:

CO1: Search primary or secondary dataset and collect the data for analysis.

CO2: Apply the statistical techniques in the project which they had learned in the theory.

CO3: Interpret and conclude the statistical analysis scientifically.

CO4: Represent his/her work through power point presentation.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY
NANDED
Choice Based Credit System (CBCS) Course Structure
Soft Skill Elective Course: Semester-I/III

STATOE01 DATA ANALYSIS WITH ADVANCED EXCEL
(02 Credit Course: Maximum 30 Periods)

- **Course objectives:** To learn analysis of various kinds of data using excel.
- **Prerequisites:** Descriptive statistics, data tabulation and representation, introduction of elementary MS-Excel.
- **Course Outcomes:**

After completion of the project students will able to:

CO1: Handle and process the data using excel.

CO2: Perform the analysis with analysis tool pack in excel.

CO3: Customize menus and toolbars in excel.

CO4: Understand and apply various functions available in excel.

UNIT I: introduction, using excel lists, creating a list, sorting, to perform a simple sort. Data forms: adding data using the data form, finding records using criteria filtering data, auto-filter, advanced filters. Totals and subtotals total row, subtotals, managing windows, multiple windows splitting windows, linking data, analysis tool pack. Analysis by goal seeks and pivot tables.

UNIT II: customizing menus and toolbars debugging, handling errors, macros, customizing menus and toolbars, writing macros, selecting cells and ranges, arguments and functions, loops and logic, debugging, handling errors, event-handling, menus and toolbars, working across applications, crib sheet.

REFERENCES:

1) Learn Excel 2016 Expert Skills with The Smart Method: Courseware Tutorial teaching Advanced Techniques, Mike Smart
2) Advance Excel 2016 Training Guide by Rita Arora
3) Microsoft Excel Data Analysis and Business Modeling, Wayne Winston.
4) Six Sigma Statistics with EXCEL and MINITAB, Issa Bass

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Choice Based Credit System (CBCS) Course Structure
STATISTICS
Soft Skill Elective Course: Semester-I/III

STATOE02 STATISTICAL ANALYSIS USING R
(02 Credit Course: Maximum 30 Periods)

- **Course objectives:** To learn the statistical analysis using 'R' free and open source software.
- **Prerequisites:** Basics of descriptive and inferential statistics, distribution theory.
- **Course Outcomes:**

After completion of the project students will able to:

CO1: Understand basics of R environment.

CO2: Perform various operations on data in R.

CO3: Do descriptive statistical analysis in R.

CO4: Compute correlation and regression lines through R.

UNIT I: Introduction to R programming, starting and ending R; Data types; Getting help in R; R use as calculator. Simple manipulations; numbers and vectors; objects, their modes and attributes; ordered and unordered factors; arrays and matrices; list and data frames; reading data from files; grouping; loops and conditional execution.

UNIT II: Descriptive Statistics: Graphical procedures and diagrammatic representation. Measures: central tendency, dispersion, skewness and kurtosis. Correlation: inference procedure for correlation coefficient, bivariate correlation, multiple correlations. Linear regression: inference and its validation, polynomial regression, multiple regressions.

References:

1) Normal Maltoff (2009) The art of R programming.
2) Purohit S. G., Gore S. D. and Deshmukh S. K. (2010) Statistics using R, Narosa.
3) W. John Braun, John Braun, Duncan James Murdoch (2007) First Course in Statistical
4) Programming with R, Cambridge University Press.
5) M. D. Ugarte, A. F. Militino, A. T. Arnholt (2008) Probability and Statistics with R,
6) CRC Press.
7) Peter Dalgaard (2008) Introductory Statistics with R, Springer.
8) Michael J. Crawley (2007) The R Book, John Wiley and Sons.
9) Rizzo, M. L., Statistical Computing with R. Chapman & Hall.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY
NANDED
Choice Based Credit System (CBCS) Course Structure
Soft Skill Elective Course: Semester-II/IV

STATOE03 INTRODUCTION TO DATA MINING
(02 Credit Course: Maximum 30 Periods)

- **Course objectives:** To learn basic data mining techniques and their handling using R software.
- **Prerequisites:** Basics of Descriptive and Inferential statistics, distribution theory and basics of R software.

- **Course Outcomes:**

After completion of the project students will able to:

CO1: Understand fundamentals of data mining.

CO2: Know feature and applications of data mining.

CO3: Understand data warehousing, OLAP, OLTP, Data visualization.

CO4: Implement and interpret the results of data scientifically using R software.

UNIT I: Fundamentals of data mining, Data mining strategies Popular Data mining techniques, Challenges of data mining, features and applications.

UNIT II: Data, information and knowledge, Types of Data, Data Warehouses, Data processing, Data cleaning, Data transformation, Data quality measure, OLAP: Data sampling Data Visualization, Data Filtering, Selecting attributes, Data mining estimation task: Scatter plots and correlation, Linear regression models, Logistic regression, Regression analysis using R software.

REFERENCES:

1) Instant Weka How-to by Botjan Kalua
2) Data Analysis with Open Source Tools: A Hands-On Guide for Programmers and Data Scientists by Philipp K. Janert
3) Exploring Geological Data with Weka, CoDaPack, and iNZight: Graphical Instructions.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY
NANDED
Choice Based Credit System (CBCS) Course Structure
Soft Skill Elective Course: Semester-II/IV

STATOE04 DATA ANALYSIS USING SPSS SOFTWARE
(02 Credit Course: Maximum 30 Periods)

- **Course objectives:** To learn statistical techniques and their implementation using comprehensive SPSS software.
- **Prerequisites:** Descriptive and Inferential statistics.
- **Course Outcomes:**
  After completion of the project students will able to:

CO1: Get familiar with SPSS software and understand SPSS environment.

CO2: Create and edit the data files, plot graphs using SPSS.

CO3: Compute descriptive statistics using SPSS.

CO4: Perform inferential statistical analysis through SPSS.

UNIT I: An Overview of SPSS: Frequently used dialog boxes, Editing output, Printing results, Creating and editing a data file. Managing Data: Listing cases, replacing missing values, computing new variables, recording variables, exploring data, selecting cases, sorting cases, merging files. Graphs: Creating and editing graphs and charts. Frequencies: Frequencies, bar charts, histograms, percentiles.

UNIT II: Descriptive Statistics: measures of central tendency, variability, deviation from normality, size and stability. Cross Tabulation and chi-square analysis. Correlation: Bivariate Correlation, Partial correlations and the correlation matrix. The T-test procedure: Independent–samples, paired samples, and one sample tests. The one way ANOVA procedure: One way analysis of variance. General Linear model, Simple and Multiple regression analysis.

REFERENCES:

1) SPSS Statistics for Data Analysis and Visualization by Jason Verlen, Andrew Wheeler, Jon Peck, Jesus Salcedo, Keith McCormick, John Wiley & Sons
2) How to Use SPSS A Step-by-Step Guide to Analysis and Evaluation 1st Edition by Brian C. Cronk.