Introduction

In September, 2000 the University Grants Commission constituted a new Curriculum Development Committee in Statistics. The Core Committee consisted of:

1. Prof. J. V. Deshpande, University of Pune (Convener)
2. Prof. N. R. Mohan, University of Mysore
3. Prof. G. K. Shukla, Indian Institute of Technology, Kanpur, and

The following were further coopted as PG members and the first meeting of the extended Committee was held on November 13/14, 2000.

(a) Postgraduate Committee

1. Prof. R. L. Karandikar, Indian Statistical Institute, New Delhi
2. Prof. S. P. Mukherjee, Calcutta University,
3. Dr A. Sarkar, IBM India Research Lab, New Delhi
4. Prof. T. Srivenkataramana, Bangalore University,

In this meeting it was decided to co-opt the following as UG members and they were invited to attend the next two meetings of the Committee.

(b) Undergraduate Committee

1. Dr B. Das, Presidency College, Calcutta,
2. Dr T. M. Durairajan, Loyola College, Chennai,
3. Dr B. R. Gupta, Venkateswara College, New Delhi
4. Dr. K. K. Madhava Rao, Bhandarkar's College, Kundapura,
5. Dr Ram Karan Singh, Lucknow University.

In the first meeting held on November 13/14, 2001, visualizing the vast diversity in different branches of Statistics, it was decided to seek further help from the following colleagues in drafting the syllabi for the various papers. They were:

1. Dr S. Adak, IBM India Research Lab, New Delhi,
2. Dr A. D. Dharmadhikari, University of Pune,
3. Prof. A. P. Gore, University of Pune,
The committees met subsequently on 15-16-17 January, 2001 and 28 Feb. -1 - 2 March, 2001. Much of the detailed work was done by the Committee members and the other colleagues at their headquarters. It was discussed and finalized in the committee meetings at New Delhi. The Committee had the benefit of discussions with Prof. A. S. Nigavekar, Vice-Chairman, UGC, during its first meeting in Nov. 2000.

The Convener reports with great pleasure and a sense of fulfillment that the utmost cooperation in this task was received from the core members, the co-opted members as well as the other colleagues listed above. The Convener thanks them heartily for their devotion to the subject and hard work. The syllabi provided here are the result of this joint effort. At the end of this report certain operative recommendations are made to the Commission. They are also the result of the concensus of the members of the Committee.

The Committee had to take into account the changes which have occurred since the publication of the last CDC report in 1989, in (a) the subject matter, (b) the revolution in computational power, (c) the general societal changes in which IT has come to play a very important role and (d) usage of Statistics in industries in the new economic order. The Committee has striven hard to take cognizance of all these aspects and has suggested the enclosed undergraduate and postgraduate syllabi, accordingly.

Now it is well recognized that the days of manual, electrical and electronic calculators have passed and Statistics is being developed and will be applied in the new Century only with the help of computers (both PC and mainframe). With this major transformation in view the Committee has suggested a full integration of computers in the instruction. This is the only way in which Statistics should now be taught. Any University not having adequate laboratory (computation) facility should not be allowed to start instruction in Statistics, at least at the postgraduate level.
Review of the Existing Syllabi

The Committee had the benefit of the CDC report finalized in November 1988 under the Chairmanship of the late Prof. C. G. Khatri. Also, the UGC Panel for Statistics constituted in 1994 had conducted a survey of the Centres of post-graduate teaching in India. It had received information including the current syllabi from about 30 universities. The members of the current CDC (the core group and the co-opted members) were from Centres situated in different parts in India and had intimate personal knowledge of the state of affairs in their own University as well as neighbouring universities. The UGC Panel for Statistics had convened two meetings (one for northern States and the other for the Southern States ) of the Conveners of the Postgraduate and Undergraduate Boards of Studies of the Universities in 1999-2000. About 60 Universities were represented. Their comments and suggestions regarding the syllabi were recorded and were available to the CDC.

It is noted that the 1988 CDC report has an exhaustive prefatory statement. We do not repeat the points made in it. Here we only emphasize the changes that have been deemed appropriate to be carried out in the following syllabi.

Undergraduate Syllabi

It is recognized that purpose of undergraduate teaching is primarily to prepare the students for post-graduate instruction and also to prepare them to hold (subordinate) positions dealing with statistical analysis. Hence these courses have to be in tune with the latest developments in the subject and also take cognizance of the newer techniques of statistical analysis which are now totally based on computers. It is taken for granted that the students will offer Mathematics as another subject at least at the General / Ancillary level.

Undergraduate B.A./B.Sc. (General / Ancillary) Course

It is noted that the structure in most of the Universities having the general degree or having Statistics as an ancillary subject with another principal subject continues to be as 2 theory papers of 100 marks each + 1 practical of 100 marks per year contributing 300 marks in each of the three years of the B.A./B.Sc. course, making up a total of 6 theory papers and 3 practical papers.

It is recognized that the students learning Statistics at the Ancillary/General level may be specializing in another subject. To do quantitative work in any subject familiarity with basic statistical methodology is necessary. While drafting this syllabus this need has been kept in view.

The contents of the subject of Statistics have now stabilized to a considerable extent. Hence the basic framework of this course remains the same as included in the 1989
syllabus. However, in view of the experience gained in these years certain modifications have been carried out emphasizing certain areas and deemphasizing certain other areas. Also a much larger role has been given to computer based methods. Familiarity with computers, computer programming and software packages is sought to be achieved in this course. This has been done as, now-a-days all the work of statistical nature is carried out through the medium of computers and this familiarity and training has become a necessary part of statistical education.
B.A/B.Sc. (General/Ancillary) Course in Statistics

<table>
<thead>
<tr>
<th>Paper Number</th>
<th>Title</th>
<th>Full or Half Year</th>
<th>Contact Hours per week</th>
<th>Marks</th>
</tr>
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<tbody>
<tr>
<td>FIRST YEAR</td>
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</tr>
<tr>
<td>101</td>
<td>Probability Theory</td>
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<td>102</td>
<td>Descriptive Statistics</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<tr>
<td>103</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<tr>
<td>SECOND YEAR</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>201</td>
<td>Statistical Methods</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>202</td>
<td>A : Sample Surveys</td>
<td>Half</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>B : Analysis and Design</td>
<td>Half</td>
<td>3</td>
<td>50</td>
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<tr>
<td></td>
<td>of Experiments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>203</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>THIRD YEAR</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>301</td>
<td>Applied Statistics</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<tr>
<td>302</td>
<td>A : Statistical Quality Control</td>
<td>Half</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>B : Computational Techniques</td>
<td>Half</td>
<td>3</td>
<td>50</td>
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<tr>
<td>303</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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</table>

Undergraduate B.A./B.Sc. (Honours / Special) Course

Here the structure usually is 2 theory papers of 100 marks each + 1 practical paper of 100 marks in the first two years and 4 theory papers of 100 marks each + 2 practical papers of 100 marks each in the third year making up a total of 8 theory papers and 4 practical papers in the three years.

Once again it is noted that due to the stability achieved in the fundamental aspects of the subject, the changes proposed during the first two years are mainly of organizational nature with certain modernization being introduced in terms of use of computers. In the third year it is now suggested that only 2 theory papers out of 4 and 1 practical out of the 2 should be compulsory. 1 theory paper and ½ practical (50 marks) should be offered out a list of several elective papers and the students be required to do a project worth the remaining 150 marks. Only if the project is not at all feasible then they may be allowed to choose another elective theory paper (100 marks) and the corresponding practical (50 marks). These elective courses contain several new and important topics such as Statistical computation, Environmental Statistics, Applied Decision Making, etc. The practical worth 50 marks will be based on the Elective paper offered. The exact syllabus of the practical is left to the respective Boards of Studies. A set of guidelines for the Project Work are provided at the end of the detailed B.A./B.Sc. (Honours) syllabus.
## B.A/B.Sc. (Honours) Course in Statistics

<table>
<thead>
<tr>
<th>Paper Number</th>
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<th>Contact Hours per week</th>
<th>Marks</th>
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<td><strong>FIRST YEAR</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>Probability I</td>
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<td></td>
<td>B : Mathematical Methods II</td>
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<td>50</td>
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<tr>
<td>102</td>
<td>Descriptive Statistics</td>
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<td>103</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<tr>
<td><strong>SECOND YEAR</strong></td>
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<td>201</td>
<td>A : Probability II</td>
<td>Half</td>
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<td>50</td>
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<tr>
<td></td>
<td>B : Mathematical Methods II</td>
<td>Half</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>202</td>
<td>Statistical Inference</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<tr>
<td>203</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td><strong>THIRD YEAR</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>Applied Statistics</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>302</td>
<td>Design of Experiments, Linear Models and</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Sample Surveys</td>
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<tr>
<td></td>
<td>Official Statistics</td>
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<tr>
<td>303</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<td>304</td>
<td>Elective Paper</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<td>305</td>
<td>Practical Based on the Elective paper</td>
<td>Full</td>
<td>1½</td>
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<td>306</td>
<td>Project</td>
<td>Full</td>
<td>4½</td>
<td>150</td>
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</table>

## LIST OF ELECTIVES

1. Elementary Stochastic Processes
2. Statistics for Environment
3. Industrial Statistics and Operational Management
4. Computation Applications
5. Applied Decision Making

**N.B.** The University Boards of Studies in Statistics may add further elective courses to this list.
Post-Graduate M.A./M.Sc. Syllabi

The new developments in the subject as well as the changes in emphasis are to be reflected to a much larger extent in the PG course as this course has several purposes. One is that it brings the students almost to the threshold of new research in the subject (with the help of pre-Ph.D. or M.Phil. courses) and secondly it prepares the students to hold responsible and superior positions which use advanced statistical methodology.

Expanding role of Statistical usage

The role of statistics as the technology of data analysis and decision making under uncertainty has expanded vastly in the past few years. Decisions regarding planning, development, spread of services, etc., whether on the national canvass or at a local scale are all based on statistical analysis. Also, developmental industries, such as biopharmaceutics, insurance, investments, market research etc. are major users of statistical methodology. In the post – liberalization scenario, in which we are committed to the WTO and GATT regimes of relatively free international movement in goods and services, it is imperative that the productivity of our processes and quality and reliability of our products match and even surpass the international standards. Statistical methods play an important role in these matters as laid down in the current ISO standards.

Need for advanced computational support

In the 21st century, as already discussed in the section on the UG syllabus, all statistical work will be carried out through the medium of fast computers. There is no role at all for old fashioned mechanical or hand held electronic calculators which have been the mainstay of our laboratories for the last 50 years. Therefore this syllabus lays the necessary stress on the computerization of the whole course. It will help the students to use effectively the tools of the IT in their work.

Major changes in the structure of the syllabus

To meet the above challenges several radical changes have been proposed in the existing syllabi. Firstly, the concept of having separate papers in practicals has been abandoned. All the numerical / practical work has been integrated with the teaching of theory courses. Secondly, after teaching 12 semester papers in the core areas, it is proposed that 6 further papers be selected from within specialized modules. Six such modules have been proposed herewith. Thirdly it is suggested that all the numerical / practical work be carried out on computers. Pentium level PC's (one for every 2 or 3 students admitted to the course) are seen to be the best vehicles for carrying out this major changeover at this time. (April, 2001).

Since the practical and theory work is being amalgamated in many papers the examinations in such papers will have to be appropriately modified. Each such examination should be conducted in two parts, possibly at different times, apportioning the total marks
in proper proportion and giving adequate time to each part. The details will have to be worked out by the respective Board of Studies.

The last component of the course is project work equivalent to two semester papers. Carrying out of projects (they may involve field work or not) is recognized to be the best way of developing the creative, problem solving and innovative faculties of the students. It brings forth the students' abilities to cope with real problems, be they of research (theoretical) or of practical nature. It helps them to become more proficient in communication skills (written as well as oral) and teaches them to work in diverse environments. The tradition of projects has long been established in other technological courses. It is sought to be introduced in Statistics through the proposed syllabus. Thus in summary the structure is as follows.
# M.A./M.Sc. Statistics Syllabus

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Title</th>
<th>Contact hours per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester I</td>
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</tr>
<tr>
<td>101</td>
<td>Real Analysis</td>
<td>3 lectures, 1 tutorial</td>
</tr>
<tr>
<td>102</td>
<td>Linear Algebra</td>
<td>3 lectures, 1 tutorial, 1 practical</td>
</tr>
<tr>
<td>103</td>
<td>Distribution Theory</td>
<td>3 lectures, 1 tutorial</td>
</tr>
<tr>
<td>104</td>
<td>Sample Surveys and Statistics for National Development</td>
<td>3 lectures, 2 Practicals</td>
</tr>
<tr>
<td>105</td>
<td>Statistical Computing</td>
<td>2 lectures, 3 practicals</td>
</tr>
<tr>
<td>Semester II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>Probability</td>
<td>3 lectures, 1 tutorial</td>
</tr>
<tr>
<td>202</td>
<td>Stochastic Processes</td>
<td>3 lectures, 1 tutorial</td>
</tr>
<tr>
<td>203</td>
<td>Inference I</td>
<td>3 lectures, 1 tutorial, 1 practical</td>
</tr>
<tr>
<td>204</td>
<td>Linear Models and Regression Analysis</td>
<td>3 lectures, 1-2 practicals</td>
</tr>
<tr>
<td>205</td>
<td>Multivariate Analysis</td>
<td>3 lectures, 2 practicals</td>
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<tr>
<td>Semester III</td>
<td></td>
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<tr>
<td>301</td>
<td>Inference II</td>
<td>3 lectures, 1 tutorial, 1 practical</td>
</tr>
<tr>
<td>302</td>
<td>Design and Analysis of Experiments</td>
<td>3 lectures, 2 practicals</td>
</tr>
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<td>303</td>
<td>Course from the selected module</td>
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<td>304</td>
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<td>404</td>
<td>-do-</td>
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<tr>
<td>405</td>
<td>Project</td>
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The Modular Structure

The following 6 modules have been proposed. Except the first, all the remaining modules include extensive statistical computing.

M-1 Probability
M-2 Advanced Statistical Analysis
M-3 Industrial Statistics and Operations Research
M-4 Biostatistics
M-5 Computational Statistics
M-6 Economic and Financial Statistics

The proposed papers in these modules and their detailed syllabi have been listed later on. The modules are not nonoverlapping. However, it is felt that as far as possible the students should be allowed to offer papers from within a single module. Each Statistics Department will have to decide how many and which of these modules should actually be taught as it may not be feasible to provide instruction in all of them. Such a choice will have to be made keeping in view the specializations of the faculty and considerations of employability of the students.

The first module is meant to go deep in the area of Probability. This will allow the students to proceed towards a research / teaching career. The second module presents advanced statistical analyses of very general applicability. Teaching this module will serve a dual purpose. The students will gain knowledge of contemporary developments in statistical analysis enabling them to make further contributions to these as well as to use the advanced methodology in new and innovative manner to emerging applied problems. Modules 3, 4 and 6 are specializations of statistical methodology as applied to manufacturing industries, biopharmaceuticals, and areas such as insurance, investments etc. Departments of Statistics envisaging a demand for personnel trained to undertake such statistical analysis should establish instruction in these modules. The fifth module - Computational Statistics is in fact the interface between Statistics, Computer Science and their applications. The courses in this module are so devised that after proper instruction the students should be capable of (i) carrying out statistical analysis using modern statistical softwares, (ii) developing softwares for use in statistical purposes, (iii) acquiring enough proficiency in computer science and programming so that they can be absorbed in the general software / IT sector. Hence the parts of the country where the IT sector is active will see a demand for students trained in these areas.

As stated earlier the Departments should offer courses from as many of the modules as possible subject to local conditions. While not totally barring students from taking courses across the modules, it should be seen that a group of allied courses is offered as far as possible. The allied courses could also be from other disciplines. For examples, the students
wishing to specialize in the Biostatistics module could be advised to take a single semester introductory paper in ‘Life Sciences’, similarly those specializing in Economic / Financial Statistics may take a course in ‘Introduction to Economics’. These allied courses may be offered by other Departments of the University.

If a student takes at least 4 elective courses from the same module then he may be certified to have specialized in that module. The project work should be related to the module of specialization.
### Module specific elective papers for the M.A./M.Sc. (Statistics) Course.
*(L : Lecture, T : Tutorial, P : Practical)*

#### Module 1 : Probability

<table>
<thead>
<tr>
<th>Courses</th>
<th>Total Contact Hours</th>
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<tbody>
<tr>
<td>M.1.1 : Advanced Distribution theory</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.1.2 : Functional Analysis</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.1.3 : Martingales</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.1.4 : Probability Measures on Metric Spaces</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.1.5 : Inference in Stochastic Processes</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.1.6 : Applied Stochastic Models</td>
<td>45L + 15P</td>
</tr>
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<td>M.1.7 : Advanced Stochastic Processes</td>
<td>45L + 15T</td>
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#### Module 2 : Advanced Statistical Analysis

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<tr>
<td>M.2.1 : Advanced Distribution Theory (same as M.1.1)</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.2.2 : Statistical Decision Theory</td>
<td>45L + 5T</td>
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<tr>
<td>M.2.3 : Bayesian Inference</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.2.4 : Nonparametric and Semiparametric Methods</td>
<td>45L + 15P</td>
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<tr>
<td>M.2.5 : Advanced Multivariate Analysis</td>
<td>45L + 20P</td>
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<tr>
<td>M.2.6 : Advanced Sampling Theory</td>
<td>45L + 30P</td>
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<tr>
<td>M.2.7 : Time Series Analysis (same as M.6.1)</td>
<td>45L + 20P</td>
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<tr>
<td>M.2.8 : Applied Regression Analysis</td>
<td>45L + 20P</td>
</tr>
<tr>
<td>M.2.9 : Advanced Design and Analysis of Experiments</td>
<td>45L + 20P</td>
</tr>
<tr>
<td>M.2.10 : Applied Stochastic Models (same as M.1.6)</td>
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#### Module 3 : Industrial Statistics and Operations Research

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<tbody>
<tr>
<td>M.3.1 : Statistical Process and Quality Control</td>
<td>45L + 20P</td>
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<tr>
<td>M.3.2 : Planning and Analysis of Industrial Experiments</td>
<td>45L + 30P</td>
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<td>M.3.3 : Reliability Theory</td>
<td>45L + 16P</td>
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<td>M.3.4 : Statistical Methods for total Quality Management</td>
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<td>M.3.5 : Operations Research I</td>
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<td>M.3.6 : Operations Research II</td>
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### Module 4: Biostatistics

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<td>M.4.1 : Bioassay</td>
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<td>M.4.2 : Statistical Genetics</td>
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<td>M.4.3 : Survival Analysis</td>
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<td>M.4.4 : Statistical Ecology</td>
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<td>M.4.5 : Quantitative Epidemiology</td>
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<td>M.4.6 : Clinical Trials</td>
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<td>M.4.7 : Demography</td>
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<td>M.4.8 : Generalized Linear Models</td>
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<td>M.4.9 : Applied Regression Analysis</td>
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### Module 5: Computational Statistics

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<tbody>
<tr>
<td>M.5.1 : Computer Intensive Statistical Methods I</td>
<td>45L + 25P</td>
</tr>
<tr>
<td>M.5.2 : Computer Intensive Statistical Methods II</td>
<td>45L + 20P</td>
</tr>
<tr>
<td>M.5.3 : Computer Programming</td>
<td>35L + 30P</td>
</tr>
<tr>
<td>M.5.4 : Knowledge Discovery and Data Mining</td>
<td>45L + 16P</td>
</tr>
<tr>
<td>M.5.5 : Statistical Pattern Recognition</td>
<td>45L + 16P</td>
</tr>
</tbody>
</table>

### Module 6: Economic and Financial Statistics

<table>
<thead>
<tr>
<th>Course</th>
<th>Total Contact Hours</th>
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</thead>
<tbody>
<tr>
<td>M.6.1 : Time Series Analysis</td>
<td>45L + 18P</td>
</tr>
<tr>
<td>M.6.2 : Econometrics</td>
<td>45L + 24P</td>
</tr>
<tr>
<td>M.6.3 : Game Theory</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.6.4 : Investments under Uncertainty</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.6.5 : Optimization in Economics</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.6.6 : Actuarial Statistics</td>
<td>45L + 15T</td>
</tr>
<tr>
<td>M.6.7 : Official Statistics</td>
<td>45L + 15T</td>
</tr>
</tbody>
</table>

The University of Boards of Studies in Statistics may add other appropriate courses to the list of module courses.

All the elective courses, except M.5.3: Computer Programming has 35 theory periods over the 15 week semester. This course requires more practicals and less theory instruction as specified. In general
the practical and the tutorial hours are not uniform. The differences reflect the thrust and
the nature of the course.

Operative Recommendations

The Committee is acutely aware that a large proportion of Post-graduate teaching
Centres in India lack the basic facility of a computer based laboratory. As a one time
measure the Committee strongly suggests that the UGC make a grant of Rs. 4.0 lacs to
any such Centre which is adopting this syllabus. At current low prices this grant will enable
the Centres to set up a statistical laboratory with 10 PC’s (at the Pentium III/Celeron level
with networking and some softwares). In such a laboratory it will be possible to train 20/25 Part I students over 3 days of the week and a similar number of Part II students over
the other 3 days of the week. A proper modus operandi for awarding this grant should be
established by the Commission. In fact it will be desirable to make such grants to UG
colleges also. However, the numbers will be large. It is therefore recommended that an
adequate computer laboratory be set up jointly with the Computer Science Departments
in those colleges which provide instruction in Computer Science also.

There is also the question of running expenses for the laboratory. This can be solved
by charging an extra laboratory fee upto Rs. 2000 per semester from the students by the
concerned institutions. The Committee is convinced that unless some such unusual
measures are taken, the recommendations of the Committee will not be put into practice.
There is a great paucity of teachers at both UG and PG levels with adequate exposure
to computers. The Committee strongly recommends that the following two measures be
taken to meet this challenge : (i) Retrain the teachers through the medium of refresher
courses, workshops, etc. The UGC should make special provision for such Refresher
Courses at a place where adequate trained personnel and infrastructure is available, such
as the Indian Statistical Institute, the University of Pune, etc. (ii) Wherever available adjunct
teachers should be appointed from the Industry, other Institutions, etc. The payment to these
adjunct teachers may be made out of the extra fees generated as suggested above.
DETAILED SYLLABI
### B.A/B.Sc. (General/Ancillary) Course in Statistics

<table>
<thead>
<tr>
<th>Paper Number</th>
<th>Title</th>
<th>Full or Half Year</th>
<th>Contact Hours per week</th>
<th>Marks</th>
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<tbody>
<tr>
<td><strong>FIRST YEAR</strong></td>
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</tr>
<tr>
<td>101</td>
<td>Probability Theory</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>102</td>
<td>Descriptive Statistics</td>
<td>Full</td>
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<td>100</td>
</tr>
<tr>
<td>103</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<tr>
<td><strong>SECOND YEAR</strong></td>
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<tr>
<td>201</td>
<td>Statistical Methods</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>202</td>
<td>A : Sample Surveys</td>
<td>Half</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>B : Analysis and Design of Experiments</td>
<td>Half</td>
<td>3</td>
<td>50</td>
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<tr>
<td>203</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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<tr>
<td><strong>THIRD YEAR</strong></td>
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</tr>
<tr>
<td>301</td>
<td>Applied Statistics</td>
<td>Full</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>302</td>
<td>A : Statistical Quality Control</td>
<td>Half</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>B : Computational Techniques</td>
<td>Half</td>
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<td>50</td>
</tr>
<tr>
<td>303</td>
<td>Practical</td>
<td>Full</td>
<td>3</td>
<td>100</td>
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</tbody>
</table>
FIRST YEAR

101 : PROBABILITY THEORY

Important Concepts in Probability: Definition of probability - classical and relative frequency approach to probability, Richard Von Mises, Cramer and Kolmogorov’s approaches to probability, merits and demerits of these approaches only general ideas to be given). (5L)

Random Experiment: Trial, sample point and sample space, definition of an event, operation of events, mutually exclusive and exhaustive events. Discrete sample space, properties of probability based on axiomatic approach, conditional probability, independence of events, Bayes’ theorem and its applications. (15L)

Random Variables: Definition of discrete random variables, probability mass function, idea of continuous random variable, probability density function, illustrations of random variables and its properties, expectation of a random variable and its properties -moments, measures of location, dispersion, skewness and kurtosis, probability generating function (if it exists), their properties and uses. (20L)

Standard univariate discrete distributions and their properties: Discrete Uniform, Binomial, Poisson, Hypergeometric, and Negative Binomial distributions. (20L)

Continuous univariate distributions- uniform, normal, Cauchy, Laplace, Exponential, Chi-Square, Gamma and Beta distributions. Bivariate normal distribution (including marginal and conditional distributions). (25L)

Chebyshev’s inequality and applications, statements and applications of weak law of large numbers and central limit theorems. (5L)

(90L)

REFERENCES


ADDITIONAL REFERENCES


102 : DESCRIPTIVE STATISTICS

Types of Data: Concepts of a statistical population and sample from a population; qualitative and quantitative data; nominal and ordinal data; cross sectional and time series data; discrete and continuous data; frequency and non-frequency data. Different types of scales - nominal, ordinal, ratio and interval. (5L)

Collection and Scrutiny of Data: Primary data - designing a questionnaire and a schedule; checking their consistency. Secondary data - its major sources including some government publications. Complete enumeration, controlled experiments, observational studies and sample surveys. Scrutiny of data for internal consistency and detection of errors of recording. Ideas of cross-validation. (5L)

Presentation of Data: Construction of tables with one or more factors of classification. Diagrammatic and graphical representation of grouped data. Frequency distributions, cumulative frequency distributions and their graphical representation, histogram, frequency polygon and ogives. Stem and leaf chart. Box plot. (15L)

Analysis of Quantitative Data: Univariate data-Concepts of central tendency or location, dispersion and relative dispersion, skewness and kurtosis, and their measures including those based on quantiles and moments. Sheppard's corrections for moments for grouped data (without derivation). (20L)


Multivariate data: Multiple regression, multiple correlation and partial correlation in three variables. Their measures and related results. (15L)

Analysis of Categorical Data: Consistency of categorical data. Independence and association of attributes. Various measures of association for two - waand three-way classified data. Odds ratio. (10L)

(90L)
REFERENCES


ADDITIONAL REFERENCES


103 : PRACTICAL

1. Presentation of data by Frequency tables, diagrams and graphs.
2. Calculation of Measures of central tendency, dispersion, skewness and Kurtosis.
3. Product Moment Correlation and Correlation ratio.
4. Fitting of Curves by the least square method.
5. Regression of two variables.
7. Multiple regression of three variables.
8. Multiple correlation and Partial correlation.
9. Evaluation of Probabilities using Addition and Multiplication theorems, conditional probabilities, and Baye’s theorems.
10. Exercises on mathematical expectations and finding measures of central tendency, dispersion, skewness and kurtosis of univariate probability distributions.
11. Fitting of standard univariate and continuous distributions. (30 Practicals)
SECOND YEAR

201 : STATISTICAL METHODS

Sampling from a distribution: Definition of a random sample, simulating random sample from standard distributions, concept of a derived distributions of a function of random variables. Concept of a statistic and its sampling distribution, Point estimate of a parameter, Concept of bias and standard error of an estimate. Standard errors of sample mean, sample proportion. Sampling distribution of sum of binomial, Poisson and mean of normal distributions. Independence of sample mean and variance in random sampling from a normal distribution(without derivation). (20L)

Statistical Tests and Interval Estimation: Null and alternative hypotheses, Types of errors, p- values, Statement of chi-square, t, and F statistics. Testing for the mean and variance of univariate normal distribution, testing of quality of two means and testing of equality of two variances of two univariate normal distributions. Related confidence intervals. Testing for the significance of sample correlation coefficient in sampling from bivariate normal distribution and for the equality of means and equality of variances in sampling from bivariate normal distributions. (30L)

Large sample tests: use of central limit theorem for testing and interval estimation of a single mean and a single proportion and difference of two means and two proportions, Fisher’s Z transformation and its uses. Pearson’s chi-square test for goodness of fit and for homogeneity for standard distributions. Contingency table and test of independence in a contingency table. (20L)

Nonparametric tests: Definition of order statistics and their distributions, Non-parametric tests, Sign test for univariate and bivariate distributions, Wilcoxon-Mann-Whitney test, Run test, median test, and Spearman’s rank correlation test. (20L)

REFERENCES


ADDITIONAL REFERENCES


202 A- SAMPLE SURVEYS

Sample Surveys, Concepts of population and sample, need for sampling, Census and sample survey, basic concepts in sampling, organizational aspects of survey sampling, sample selection and sample size. (10L)

Some basic sampling methods- simple random sampling (SRS) with and with out replacement. (8L)

Stratified random sampling, Systematic sampling, ratio and regression methods of estimation under SRS. (15L)

Non sampling errors, acquaintance with the working (questionnaires, sampling design, methods followed in field investigation, principal findings etc.) of NSSO, and other agencies undertaking sample surveys. (12L)

B- ANALYSIS AND DESIGN OF EXPERIMENTS

Analysis of variance for one way and two-way classifications. (10L)

Need for design of experiments, fundamental principles of design, basic designs - CRD, RBD, LSD and their analysis. (20L)

Factorial designs - 2 ^ n designs, illustrations, main effects and interaction effects and confounding in 23 design. (15L)

REFERENCES


Das M.N and Giri (1986): Design and Analysis of Experiments, Springer Verlag


ADDITIONAL REFERENCES


203 : PRACTICAL

1. Drawing random samples from standard univariate discrete and continuous distributions such as binomial, Poisson, Normal, Cauchy and exponential.


3. Large sample tests for means and proportions, tests of goodness of fit and independence of attributes in contingency tables.

4. Nonparametric tests- Sign, Run, Median and Wilcoxon- Mann- Whitney tests. Selection of sample and determination of sample size, simple random sampling, Stratified SRS, and systematic sampling, Allocation problems in stratified SRS, Ratio and Regression methods of estimation in SRS.


(30 Practicals)
THIRD YEAR

301 : APPLIED STATISTICS

Indian Applied Statistical System: Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations, and the principal publications containing such statistics on the topics- population, agriculture, industry, trade, price, labour and employment, transport and communications, banking and finance. (15L)


Economic Statistics: Index number- its definition, applications of index numbers, price relatives and quantity or volume relatives, link and chain relatives, problems involved in computation of index numbers, use of averages, simple aggregative and weighted average methods, Laspeyre’s, Paasche’s and Fisher’s index numbers, time and factor reversal tests of index numbers. Consumer Price Index. (20L)

Static laws of demand and supply, price elasticity of demand, analysis of income and allied size distribution - Pareto distribution, graphical test, fitting of Pareto’s law, log normal distribution and its properties, Lorenz curve and estimation of elasticity from time series data. Gini’s coefficient. (15L)

Time Series Analysis: Economic time series, its different components, Illustrations, additive and multiplicative models, determination of trend, growth curves, analysis of seasonal fluctuations, construction of seasonal indices. (15L)

REFERENCES


ADDITIONAL REFERENCES


Pressat R (1978) : STATISTICAL Demography, Methuen and Co. Ltd.

302 :A - STATISTICAL QUALITY CONTROL

Importance of statistical methods in industrial research and practice, specification of items and lot qualities corresponding to visual gauging, count and measurements, types of inspection, determination of tolerance limits. General theory of control charts, causes of variation in quality, control limits, sub-grouping, summary of out-of control criteria, charts for attributes, np chart, p-chart, c-chart, u-chart, Charts for variables- X- and R charts, design of X and R charts versus p-charts, process capability studies. (30L)

Principle of acceptance sampling- problem of lot acceptance, stipulation of good and bad lots, producer’s and consumers risks, single and double sampling plans, their OC functions, concepts of AQL, LTPD, AOQL, average amount of inspection and ASN function, rectifying inspection plans, Sampling inspection plans, Indian Standards Tables Part I (including applications), IS 2500 Part I. (15L)

B - COMPUTATIONAL TECHNIQUES

Computational techniques: Difference tables and methods of interpolation, Newton’s and Lagrange’s methods of interpolation, Divided differences, numerical differentiation and integration, Trapezoidal rule, Simpson’s one-third formula, iterative solution of non-linear equations. (15L)

Linear Programming : Elementary theory of convex sets, definition of general linear programming problems(LPP),formulation problems of LPP, examples of LPP, Problems occurring in various fields, graphical and Simplex method of solving an LPP, artificial variables, duality of LPP,Transportation Problem (non-degenerate and balanced cases only), Assignment Problem. (30L)

REFERENCES


ADDITIONAL REFERENCES


303 : PRACTICAL


2. Construction of Index Numbers by Laspeyre’s, Paasche’s, Fisher’s method.

3. Determination of trend in a time series, construction of seasonal indices.

4. Fitting of Pareto curve to income data, Lorenz curve of concentration, estimation of price elasticity of demand form time series data.


6. Construction of difference tables, use of Newton’s Lagrange’s methods of interpolation and divided difference formulae, numerical evaluation of integrals using Trapezoidal and Simpson’s one-third formulae, solution of non-linear equation by Newton-Raphson iterative method.

7. Formulation of LPP’s and their duals. Solving LPPs by graphical and simplex methods, transportation and assignment problems.

(30 Practicals)

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<thead>
<tr>
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<tr>
<td>101</td>
<td>A : Probability I</td>
<td>Half</td>
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<td>B : Mathematical Methods II</td>
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<td>50</td>
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<tr>
<td>102</td>
<td>Descriptive Statistics</td>
<td>Full</td>
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<td>202</td>
<td>Statistical Inference</td>
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<tr>
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<td>301</td>
<td>Applied Statistics</td>
<td>Full</td>
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<td>100</td>
</tr>
<tr>
<td>302</td>
<td>Design of Experiments, Linear Models and Sample Surveys</td>
<td>Full</td>
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<tr>
<td>304</td>
<td>Elective Paper</td>
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<td>Practical (Elective)</td>
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<tr>
<td>306</td>
<td>Project</td>
<td>Full</td>
<td>1½</td>
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</tbody>
</table>

**LIST OF ELECTIVES**

1. Elementary Stochastic Processes
2. Statistics for Environment
3. Industrial Statistics and Operational Management
4. Computation Applications
5. Applied Decision Making

**FIRST YEAR**
101 A : PROBABILITY

Random experiment: trial, sample point and sample space, event, Operations of events, concepts of mutually exclusive and exhaustive events. (5L)

Definition of probability : classical and relative frequency approach. Discrete probability space, Properties of probability, Independence of events, Conditional probability, total and compound probability rules, Bayes' theorem and its applications. (10L)

Discrete random variable (rv); its probability mass function (pmf) and cumulative distribution function (cdf). Joint pmf of several discrete rv's. Marginal and conditional pmfs. Independence of rv's. Expectation of a rv and its properties. Moments, measures of location and dispersion of a rv. Probability generating function (pgf) and moment generating function (mgf) of a rv, their properties and uses. (15L)

Standard univariate / bivariate discrete distributions: degenerate, discrete uniform, binomial, hypergeometric, Poisson, geometric and negative binomial distributions. Marginal and conditional distributions, Distributions of functions of discrete rv's, reproductive property of standard distributions. (15L)

REFERENCES


101.B: MATHEMATICAL METHODS -1

Vector space with real field; linear combination of vectors; subspaces; Examples in R with geometrical interpretation; Linear dependence and independence of vectors; Dimension and basis of a vector space. (10L)

Matrices; types of matrices; operation on matrices; partitioned matrices; determinants; singular and nonsingular matrices. (8L)

Rank of a matrix; row-rank and column- rank, properties of rank, rank of sum and
product of matrices; Inverse of a matrix; Orthogonal matrix; Idempotent matrix. (7L)

Linear equations, homogeneous and non homogeneous system of equations; solution space; consistency and general solution. (10L)

Sequences and series of real numbers: convergence, Cauchy criterion and simple tests for convergence. (10L)

REFERENCES


102 : DESCRIPTIVE STATISTICS

Types of Data : Concepts of a statistical population and sample from a population; qualitative and quantitative data; nominal and ordinal data; cross sectional and time series data; discrete and continuous data; frequency and non-frequency data. Different types of scale - nominal, ordinal, ratio and interval. (5L)

Collection and Scrutiny of Data: Primary data - designing a questionnaire and a schedule; checking their consistency. Secondary data - their major ources including some government publications. Complete enumeration, controlled experiments, observational studies and sample surveys. Scrutiny of data for internal consistency and detection of errors of recording. Ideas of cross-validation. (5L)

Presentation of Data : Construction of tables with one or more factors of classification. Diagrammatic and graphical representation of non-frequency data. Frequency distributions, cumulative frequency distributions and their graphical and diagrammatic representation - column digram, histogram, frequency polygon and ogives. Stem and leaf chart. Box plot. (15L)

Analysis of Quantitative Data : Univariate data: Concepts of central tendency or location, dispersion and relative dispersion, skewness and kurtosis, and their measures including those based on quantiles and moments. Sheppard’s corrections for moments for
grouped data (without derivation). Measures of inequality - Gini's coefficient and Lorenz Curve. (20L)


Multivariate data: Multiple regression, multiple correlation and partial correlation in 3 variables. Their measures and related results. (12L)

Analysis of Categorical Data: Consistency of categorical data. Independence and association of attributes. Various measures of association for two-way and three-way classified data. Odds ratio. (8L)

Scaling of Data: Motivation for scaling. Measurement for psychological traits. Scaling of items according to difficulty. Scaling of test scores. Scaling of rates and ranks. Scaling of judgments. (10L)

REFERENCES


ADDITIONAL REFERENCES


103 : COMPUTER APPLICATIONS AND PRACTICAL I

Historical evolution of computers, Generations of Computers, Classification of
Computers, Hardware : CPU, I/O Devices, Block diagram. System Software. MS-DOS :
Filenames, Creating, Editing and Printing of Files. Other File Management Commands, Disk-
Management Commands.

Find Features, Properties, Font Management, Systems Tools, Character Map, Note Pad,
The My Computer ICON, Folders, Short-Cuts.

Word Processing : Creating and Saving a document, Editing the text; Printing
Documents.

Working with Software Packages : MS-Excel, Minitab, SPSS or SYSTAT.

1. Classification, Tabulation and Frequency Tables.
2. Bar Graphs, DOT Diagram and Histogram
4. Box Plots.
5. Summary Statistics
6. Two-way tables and plots.
7. Product moment correlation coefficient, Rank Correlation coefficient.
8. Curve setting by method of least squares : Exponential and polynomial (upto three
degree) equations.
9. Regression lines
11. Multiple and partial correlation coefficients. Regression equations (for three variables
only).
12. Gram-Schmidt orthonormalization process.
13. Rank and Inverse of a matrix
15. Fitting of Binomial, Poisson, Negative Binomial, Normal and Gamma Distributions.

Programming with FORTRAN (A) :

Introduction to FORTRAN 77 or 90, FORTRAN Character codes, constants, variables,
names; arithmetic, logical and relation operators, Expressions : Arithmetic, Character,
Relation and Logical expressions. Rules for writing arithmetic expressions.

Statements : Specification Data, Parameter, Format, one dimensional Array statements,
Assignment Statements, Arithmetic Statement, Control Statements : DO loops, Do-Continue,
IF-Blocks, Unconditional GOTO, IF (condition) GOTO label, and Computed GOTO statements, STOP, RETURN and END statements.

I/O Statements : Format free Read, Write and Print Statements, Simple Formats, OPEN and CLOSE statements.


FORTRAN Programmes for :

1. Factorial of a positive Integer
2. Ordering of a given set of observations
3. Finding maximum and minimum of a given set of observations.
4. Mean, variance and quantiles for ungrouped and grouped data.
5. Correlation coefficients for ungrouped data, Intra-class correlation coefficient.
6. Fitting of exponential curve and straight line to the given data.
7. Fitting of Binomial and Poisson distributions.
8. Calculating the correlation coefficient for grouped data.

(90 hours)

REFERENCES

Norton, Peter : Guide to MS-DOS.
Mathur, Rajiv: Learning Windows -98 Step by step. Galgotia
SECOND YEAR

201 A : PROBABILITY II

General probability space : Sigma algebra of events; axiomatic definition of probability; random variable (rv), cumulative distribution function (cdf) of a rv and its properties; continuous rv and its probability density function (pdf); Expectation, moments and quantiles.  

(12L)

Univariate continuous distributions and their properties: uniform, beta, gamma, exponential Pareto, Weibull, Laplace, normal, Cauchy, logistic, lognormal; Truncated distributions, Moment generating function (mgf): its properties and applications.  

(12L)

Cdf of rv's; independence of rv's, sampling distribution of sample mean for normal and sample total for binomial, Poisson, negative binomial, normal and Gamma distributions. Chisquare, t and F distributions as distributions of functions of standard normal rv's.  

(8L)


(8L)

Tchebycheff's inequality, convergence in distribution and in probability, convergence of binomial to Poisson and of binomial to normal (Demoivre - Laplace limit theorem), statement and applications of WLLN and CLT.  

(5L)

(45L)

REFERENCES


201 B : MATHEMATICAL METHODS - 2


Function of one variable: limit, continuity and differentiability. Mean value theorems; Maxima and minima. Power series, uniform convergence. (10L)

Riemann integral; integration by parts, change of variables; improper integrals, beta and gamma integrals. (10L)

Function of several variables: partial derivatives; maxima and minima, constrained maxima and minima; applications of Lagrangian multipliers; multiple integrals, transformations and Jacobians. (15L)

REFERENCES


202 : STATISTICAL INference

Introduction : Parametric models, parameters; random sample and its likelihood; statistic and its sampling distribution; problems of inference. (2L)

Data Reduction: Sufficiency, Factorization Theorem (proof of discrete case only), Illustrations, Concept of Minimal Sufficiency. (3L)

Point Estimation : Properties of estimators: Mean square error (MSE) and minimum MSE estimator; Unbiasedness and Minimum Variance Unbiased Estimator (MVUE) Rao-Cramer Lower Bound of Variance and related results. Relative efficiency of an estimator.

Methods of Estimation: Method of Moments, Method of maximum likelihood. Statement of properties of MLE, Method of Minimum chi-square. (8L)


Interval Estimation: Concepts of Confidence Interval and Confidence Coefficient. Confidence Intervals for the Parameters of univariate normal, two independent normal and one-parameter exponential distribution. (5L)

Sequential Tests: Need for Sequential tests, Wald’s SPRT with illustrations. Approximate OC and ASN functions for tests regarding parameters of binomial and normal distributions. (7L)

Large Sample Tests: Use of CLT for deriving large sample tests for binomial proportion, difference of two binomial proportions, mean of a population and difference of means of two independent populations. Related confidence intervals. Variance-stabilizing transformations (arcsine, square-root and z) and their uses in large sample tests and interval estimation. Pearsonian Chi-square tests for independence of attributes, homogeneity of populations and goodness of fit. (20L)

Nonparametric Tests: Need for non-parametric tests. Sign test for location of univariate and bivariate populations; Wilcoxon-Mann-Whitney test; Run Test, Median test and Test based on Spearman’s rank correlation. (10L)

REFERENCES


ADDITIONAL REFERENCES


203 : COMPUTER APPLICATIONS AND PRACTICAL II

Programming with FORTRAN (B) - Towards Better Programms : REAL, INTEGER, DOUBLE PRECISION, COMPLEX and LOGICAL variables, COMMON Statement, COMMON BLOCKS, BLOCK DATA, EQUIVALENCE, Two Dimensional and Multidimensional Arrays.

Multi-branch Transfer of control : Logical and Arithmetic IF, Computed GOTO, Assigned GOTO, Nested and Implied DO Loops, Counting loops, Simple and nested Blocks:

IF-THEN
IF-THEN-ENDIF
IF-THEN-ELSE-ENDIF
IF-THEN-ELSEIF-THEN-ENDIF
DO WHILE.

Format refinements.

Design of Modular Programs : User defined functions, Function-Sub-programs, Subroutine-Subprograms. Programs using sub-programs : Square-root subroutine, Matrix inversion, Sub-programs for computing mean variance and covariance for n pairs of observations, Main programs for computing correlation-coefficient and regression lines using sub-programs.

Application of packages (SPSS, Minitab or SYSTAT) and FORTRAN Programs for solving the following problems:

1. Drawing of random samples from Binomial, Poisson, Normal and Gamma distributions.
2. Fitting of standard distributions and tests for goodness of fit.


4. Tests of significance : Drawing of power curve of a test. Test based on Chi-square, t and F statistics and related confidence intervals. Large sample tests.


7. Trapezoidal Rule, Simpson’s 1/3rd rule and Weddle’ formula for numerical integration. Comparision of values obtained by different formulae.

(90 Hours)

REFERENCES


Sastry, S.S. : Introductory Methods of Numerical Analysis, PHI India.
THIRD YEAR

301 : APPLIED STATISTICS


Statistical Process And Product Control : Quality of a product, need for quality control, Basic concepts of Process control, Process capability and Product Control.


Principles of acceptance sampling : Problem of lot acceptance, good and bad lots, producer’s & consumer’s risks, single, double and sequential sampling plans for attributes and their OC functions, concepts of AQL, LTPD, AOQL, average amount of inspection and ASN functions. Rectifying inspection plans, sampling plans for variables. Bureau of Indian Standards IS 25000 Table 1 and applications. (15L)


Analysis of income and allied distributions - Pareto distribution, graphical test, fitting of Pareto’s law, illustrations, log-normal distribution and its properties, Lorenz curve, Gini’s coefficient.

Index Numbers - Price relatives and quantity or volume relatives. Link and chain relatives, computation of index numbers, Laspeyre’s, Paasche’s, Marshal - Edgeworth’s and Fisher’s index numbers, chain base index number, consumer price - index numbers. Tests for index numbers: Time and Factor reversal tests. (25L)

Demand Analysis : Theory and analysis of consumer’s demand: Law of demand, Price elasticity of demand, Estimation of demand curves; Forms of demand functions, Engel’s curves, Income elasticity of demand. (10L)

(90L)
REFERENCES


302 : DESIGN OF EXPERIMENTS, LINEAR MODELS, SAMPLE SURVEYS AND OFFICIAL STATISTICS


Regression Analysis : Estimation and tests of regression parameters in uni-variate (linear, quadratic and cubic) and multivariate linear regression under usual assumptions and related interval estimation. Violation of usual assumptions concerning normality, homoscedasticity and collinearity. Diagonostics using probability plots.

ANOVA : Decomposition of sum of squares in one-way and two-way orthogonal classifications. ANOVA Table. (25L)
**Design of Experiment**: Need for design of experiments, Fundamental principles of design of experiments, Basic designs-CRD, RBD, LSD and their analyses, Orthogonality of classification in two-way lay-outs, advantages of orthosonality relation, simple illustrations. Analysis of co-variance, missing plot technique.

Factorial experiments: 2n, 32 factorial experiments, illustrations, main effects and interactions, confounding and illustrations. (25L)

**Sample Surveys**: Concepts of population and sample, need for sampling, census and sample surveys, Basic concepts in sampling and designing of large scale surveys. Simple random sampling with and without replacement, Stratified random sampling, Allocation problems, Systematic sampling, Cluster sampling, Ratio, Product and Regression methods of estimation. Double sampling. Two-stage and Multi-stage sampling. Non-sampling errors. Randomized response technique (Warner’s model only). (25L)

**Indian official statistics**: Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications, banking and finance. Various official agencies responsible for data collection and their main functions. (15L)

(90L)

**REFERENCES**


303 : COMPUTER APPLICATIONS AND PRACTICAL III

Use of software packages (SPSS, Minitab or SYSTAT) and FORTRAN Programs for solving the following problems :


2. One-way and two-way ANOVA (orthogonal case only).

3. Analyses of CRD, RBD, LSD. Analysis of covariance.

4. Factorial Experiments : 2n, 32 factorial experiments and confounding.


10. Construction of index numbers by Laspeyre’s, Paasche’s, Fishers’s and Marshal-Edqeworth’s formulae. Chain Base Index Number, Consumer’s Price Index Numbers.

(90 hours)
ELECTIVE 1 : ELEMENTS OF STOCHASTIC PROCESSES

Basic concepts: Definition and examples of stochastic process, classification of general stochastic processes into discrete/continuous time, discrete/ continuous state spaces, types of stochastic processes, elementary problems. (10L)

Markov chains: Definition and examples of Markov chain, Transition Probability Matrix, classification of states, recurrence, simple problems, basic limit theorem of Markov chain (statement only), stationary probability distribution, applications. (40L)

Continuous Time Markov Chain: Pure birth process and Poisson process, Birth and Death process, Problems. (20L)

Branching Process: Definition and examples of discrete time branching process, probability generating function, mean and variance, probability of extinction, problems. (20L)

REFERENCES


ELECTIVE 2 : STATISTICS FOR ENVIRONMENT

Statistical Genetics.
Cells, Chromosomes, Gametes, Genes and Gene frequency, Mendel's laws. Single locus with two alleles. Hardy-Weinberg equilibrium.
A-B-O bloodgroup system. Calculation of probabilities of offspring bloodgroup for given parental blood group. Chance of incompatibility. (25L)
Definition of ED50, ED90 etc. Simple method of estimation of the above. Data: Dose levels \((Z_i)\), number of individuals exposed \((n_i)\), number responding \((r_i)\). Simple regression of probit on log dose to estimate parameters of tolerance distribution.

Introduction to logistic regression with binary response and one independent variable (continuous). (25L)

Exponential and logistic models of population growth, solving the following differential equations:

\[
\frac{dN_t}{dt} = KN_t, \quad \frac{dN_t}{dt} = aN_t(K-N_t).
\]

Fitting the above growth models to data by linearization and regression.

Capture-recapture method of abundance estimation. One and two recapture occasions. Use of likelihood under binomial distribution.

Concept of biodiversity. Simpson’s and Shannon-Wiener indices. (25L)

Study of exponential and Weibull distributions as models for survivorship data. Corresponding hazard functions and interpretation of their shapes. Applications to environmental data. (15L)

REFERENCES


C.C. Li (1976) : First Course in Population Genetics, Boxwood Press.


ELECTIVE 3 : INDUSTRIAL STATISTICS AND OPERATIONS MANAGEMENT

Part-1 : Operations Research: Linear programming problems (LPP): Canonical and standard forms, and dual of an LPP, graphical method to solve two variable LPP, solving LPP manually using Simplex procedure in presence of slack or/and surplus or/and artificial variables, solving LPP using computer package Applications of LPP: representation of
transportation and assignment problems as LPP. Solution of a transportation problem using
initial basic feasible solution by North West corner, matrix minimization and Vogels method.
Solution of assignment problem using Hungarian method.

CPM and PERT: determination of critical path and calculation of probabilities of
completing a project with in specified period. (30L)

Part-2: Inventory planning: Concept of planned inventory policies. Deterministic Models-
policy when inventory levels are reviewed continuously and demands occur uniformly with
and without shortage costs, Economic order quantity, policy for production planning when
inventory levels are reviewed periodically, solving special cases using computer package.

Stochastic models- a single period model with no set up cost having zero or non-
zero initial stock {( s, S) policy } (4), solving special cases of these stochastic models when
demand distribution is specified using computer package. (20L)

Part 3: Forecasting: Concept of forecasting and its applications in manufacturing and
non manufacturing industrial situations, different methods of forecasting including average,
last value, weighted average (exponential smoothing), forecasting in presence of linear
trends using least square methods, forecasting in presence of seasonal effects, solving
special cases using computer package. (15L)

Part 4: Reliability: definitions and relationships between survival function, hazard
function, hazard rate of a non negative random variable, parametric distributions - Weibull,
gamma, lognormal and exponential as life time distributions, concept of aging, IFR, IFRA
classes of distributions and their dual, coherent system as binary function: minimal cut and
path sets(vectors), representation of structure function of series, parallel and k out of n : G
systems of independent components. Using minimal cut and path structure functions, dual
of a coherent structure, derivation of reliabilities of above structures. (25L)

REFERENCES


L. J. Bain and M. Englhardt: Statistical analysis of reliability and life testing models,

S. Zacks: Introduction to reliability analysis Probability models and statistical methods,

R. E. Barlow and F. Proschan: Statistical theory of reliability and life testing: Probability
ELECTIVE 4 : PROGRAMMING WITH C


Control Construct - I

Control Statements, conditional statements, if...else, Nesting of if....else, elseif ladder, switch statements, Loops in C : for, while, do... while loops.

Control Constructs - II

break, Continue, exit( ), goto and label declarations. (15L)

One dimensional, two dimensional and multidimensional arrays.

Functions, classification of functions, functions definition and declaration, assessing a function, return statement.

Storage classes : Automatic variables, External variables, static variables, register variables, Scope and lifetime of declarations.

Parameter Passing in functions, recursion in Functions.

Pointers; Pointer Notation : and * operators.

Pointer declaration and Initialization, Accessing a variable through pointer, pointer expressions, pointer arithmetic, pointer comparison, pointer increment/decrement and scale factor.

Pointer and Array : Pointers and one dimensional arrays, dynamic memory allocation functions malloc and calloc, pointers and multidimensional arrays, arrays of pointers.

Pointer and functions : Pointers to pointers, pointers and functions, pointers to functions, function returning pointers, functions with variable number of arguments. (15L)

Structure : Definition and declaration, structure (initialization, comparison of structure variables, array of structures; array within structures, structures within structures. Passing structures to functions; structure pointers. Unions - Definition and declaration, Accessing a union member, union of structure, initialization of a union variable, uses of union.
Introduction to linked list, linear linked list, insertion of a node in list, removal of a node from list.


Preprocessors

Introduction to preprocessors, Macro Substitution, Simple Macro Substitution, Macro with arguments, Nesting of Macros, Undefining a Macro, File inclusion, Conditional Compilation Directives.

Standard header files, Library functions. String functions, Mathematical functions, Date and Time functions, variables argument list function, utility functions, character class test functions. (20L)

(50 Theory + 40 Laboratory hours besides the practical paper associated with this theory paper)

REFERENCES

Gottfried, Byron S.: Theory and problems of programming with C. TMH
Schildt, Herbert: C: The complete reference III Ed.. TMH.

ELECTIVE 5. APPLIED DECISION-MAKING

The decision problem—goals and objectives, conflict between goals, possible solutions, constraints, feasible solutions, objective function, costs and benefits, notions and criteria for optimality. Steps in decision-making: determining objective(s), identifying alternative feasible solutions, determining (expected) costs and benefits associated with a feasible solution, developing a measure of effectiveness, finding the optimal solution. Sensitivity analysis and post-optimality problems. Controlling a solution. (10L)

The structure of decisions, development of the pay-off measure, Bernoullian utility, expected value, pay-off without a natural measure. The standard gamble. Strategies and states of nature. (5L)

The analysis of decisions, the pay-off matrix, decisions under certainty, uncertainty, risk and competition; optimality criteria of pessimism, optimism and regret. A decision among decision criteria. Laplace criterion. (8L)
Sequential decisions, decision trees, informal analysis of decision trees, cutting decision trees. (6L)

Decision-making using expected money value and utility, expected Profit with perfect information, conditional profits, value of perfect information, value of sample information, expected net gain due to sampling. (8L)

Decisions under competition, two-person zero-sum games, games in normal and extensive forms, pure and mixed strategies, saddle points, dominance principle, uniqueness of value, solving 2x2 games, solving 2xm games graphically, co-operative, competitive and vindictive solutions. Elements of non-zero sum games, equilibrium points. (15L)

Decision problems in production—allocation of resources and linear programming formulations, the transportation problem, the assignment problem, economic order quantity model for inventory, inventory problems with random demand, critical path methods for production planning—PERT and CPM, project crashing. (20L)

Decision problems in marketing—brand-loyalty model, brand-share model, pricing problem, competitive bidding, allocation of advertising funds. (10L)

Decision problems in finance—investment decision trees, risk analysis, portfolio selection, dividend policy. (8L)

REFERENCES


Guidelines for the Project Work : B.Sc. Statistics (Honours):
1. A project work shall be normally offered in the third year of the honours program.
2. A project work shall be spread over the complete academic year.
3. A project work shall be assessed for a maximum of 150 marks. The assessment will be based on the project report (100 marks), presentation (25 marks) and viva-voce (25 marks).

4. A project may be undertaken by a group of students and the maximum number of students in a team shall not exceed five. However, the project report shall be submitted by each member of the team separately.

   A project work shall be supervised by a faculty member assigned by the Head of the Department.

   There shall be an external examiner and an internal examiner (preferably the supervisor) for the evaluation of the project work.

   A project work should encourage a student to be able to interact with the end user.

   A project work should be chosen such that there is enough scope to apply and demonstrate the statistical techniques learnt in the honours program.

   A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and hypotheses formulated, any previous references to the study undertaken, statistical analyses performed and the broad conclusion drawn.
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<thead>
<tr>
<th>Course No.</th>
<th>Title</th>
<th>Contact hours per week</th>
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<tbody>
<tr>
<td><strong>Semester I</strong></td>
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<tr>
<td>101</td>
<td>Real Analysis</td>
<td>3 lectures, 1 tutorial</td>
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<tr>
<td>102</td>
<td>Linear Algebra</td>
<td>3 lectures, 1 tutorial, 1 practical</td>
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<tr>
<td>103</td>
<td>Distribution Theory</td>
<td>3 lectures, 1 tutorial</td>
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<tr>
<td>104</td>
<td>Sample Surveys and Distribution for National Development</td>
<td>3 lectures, 2 Practicals</td>
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<tr>
<td>105</td>
<td>Statistical Computing</td>
<td>2 lectures, 3 practicals</td>
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<tr>
<td><strong>Semester II</strong></td>
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<tr>
<td>201</td>
<td>Probability</td>
<td>3 lectures, 1 tutorial</td>
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<td>202</td>
<td>Stochastic Processes</td>
<td>3 lectures, 1 tutorial</td>
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<tr>
<td>203</td>
<td>Inference I</td>
<td>3 lectures, 1 tutorial, 1 practical</td>
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<tr>
<td>204</td>
<td>Linear Models and Regression Analysis</td>
<td>3 lectures, 1-2 practicals</td>
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<tr>
<td>205</td>
<td>Multivariate Analysis</td>
<td>3 lectures, 2 practicals</td>
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<tr>
<td><strong>Semester III</strong></td>
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<td>301</td>
<td>Inference II</td>
<td>3 lectures, 1 tutorial, 1 practical</td>
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<tr>
<td>302</td>
<td>Design and Analysis of Experiments</td>
<td>3 lectures, 2 practicals</td>
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<td>304</td>
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<td>305</td>
<td>Project</td>
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<td><strong>Semester IV</strong></td>
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<td>Project</td>
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SEMESTER I

101 : REAL ANALYSIS

Recap of elements of set theory; Introduction to real numbers, Introduction to n-dimensional Euclidian space; open and closed intervals (rectangles), compact sets, Bolzano - Weirstrass theorem, Heine – Borel theorem. (15L)

Sequences and series; their convergence. (7L)

Real valued functions, continuous functions; uniform continuity, sequences of functions, uniform convergence; Power series and radius of convergence. (8L)

Differentiation, maxima - minima of functions; functions of several variables, constrained maxima - minima of functions. Multiple integrals and their evaluation by repeated integration. change of variables in multiple integration. Uniform convergence in improper integrals, differentiation under the sign of integral - Leibnitz rule. (15L)

(45L + 15T)

REFERENCES


102 : LINEAR ALGEBRA

Fields, vector spaces, subspaces, linear dependence and independence, basis and dimension of a vector space, finite dimensional vector spaces, completion theorem, examples of vector spaces over real and complex fields, linear equations. (6L)

Vector spaces with an inner product, Gram-Schmidt orthogonalization process, orthonormal basis and orthogonal projection of a vector. (4L)

Linear transformations, algebra of matrices, row and column spaces of a matrix, elementary matrices, determinants, rank and inverse of a matrix, null space and nullity, partitioned matrices, Kronecker product. (6L)

Hermite canonical form, generalized inverse, Moore-Penrose generalized inverse, Idempotent matrices, Solutions of matrix equations. (5L)

Real quadratic forms, reduction and classification of quadratic forms, index and signature, triangular reduction of a positive definite matrix. (6L)
Characteristic roots and vectors, Cayley - Hamilton theorem, minimal polynomial, similar matrices, algebraic and geometric multiplicity of a characteristic root, spectral decomposition of a real symmetric matrix, reduction of a pair of real symmetric matrices, Hermitian matrices.

Singular values and singular value decomposition, Jordan decomposition, extrema of quadratic forms, vector and matrix differentiation.

REFERENCES


ADDITIONAL REFERENCES


103 : DISTRIBUTION THEORY


Compound, truncated and mixture distributions. Conditional expectation, correlation, multiple and partial correlation. Linear and multiple regression.

Markov, Holder, Jensen and Liapunov inequalities.

Sampling distributions. Non-central chi-square, t- and F- distributions and their properties. Distributions of quadratic forms under normality and related distribution theory. (10L)

Order statistics- their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distributions (Statement only) with applications. (7L)

REFERENCES


ADDITIONAL REFERENCES


104 : SAMPLE SURVEYS AND STATISTICS FOR NATIONAL DEVELOPMENT

A. Sample Surveys : Review of basic finite population sampling techniques [srs wr/wor, stratified, systematic] and related results on estimation of population mean/total. Allocation problem in stratified sampling. (5L)

Unequal probability sampling: pps wr/wor methods [including Lahiri's scheme] and related estimators of a finite population mean [Hansen-Hurwitz and Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2]. (8L)

Ratio and regression estimators based on srswor method of sampling. Two-stage sampling with equal number of second stage units. Double sampling. Cluster sampling. (8L)

Randomized response technique [Warner's model : related and unrelated questionnaire methods] (4L)

(25L + 15P)
REFERENCES


B. Statistics for National Development.

Economic development: Growth in per capita income and distributive justice. Indices of development, Human Development Index.

Estimation of national income - product approach, income approach and expenditure approach.


Measuring inequality in incomes, Gini coefficient, Theil’s measure.

Poverty measurement - different issues, measures of incidence and intensity, combined measures e.g., indices due to Kakwani, Sen etc.

REFERENCES


105: STATISTICAL COMPUTING

Programming in a high level language such as C (preferred) or FORTRAN. The purpose of this unit is to introduce programming with the eventual aim of developing skills required to write statistical software. Should there be previous exposure to programming,
this unit can be replaced by a more advanced unit in object-oriented programming in C++ or Java. Topics should include simple syntax, loops, pointers and arrays, functions, input/output, and linking to databases. (10L)

Numerical analysis and statistical applications. The purpose of this unit is to apply programming skills in methods and algorithms useful in probability, statistics, and data analysis. Topics should include numerical integration, root extraction, random number generation, Monte Carlo integration, and matrix computations. Should there be previous exposure to numerical analysis, more advanced techniques such as permutation tests and simulation of Poisson processes can be presented. (10L)

A statistical package such as MINITAB, SAS, or SPSS. The purpose of this unit is to use a statistical package to carry out statistical procedures already known to students. No 'new' statistical methods should be presented but interesting data can be analyzed using known methods on the package. Topics should include graphics, descriptive statistics, representation of multivariate data, simple hypothesis tests, analysis of variance, and linear regression. (10L)

REFERENCES


Note on suggested books: The choice of textbooks and references depends on the programming language and statistical package used. The above assumes C and MINITAB.
SEMESTER II

201 : PROBABILITY

Classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma-field in $\mathbb{R}_k$, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue-Steljes measures on $\mathbb{R}_k$. (12L)

Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Integration of a measurable function with respect to a measure, Monotone convergence theorem, Fatou’s lemma, Dominated convergence theorem. (12L)

Borel- Cantelli Lemma, Independence, Weak law and strong law of large numbers for iid sequences, Definition and examples of Markov dependence, Exchangeable sequences, m-dependent sequences, stationary sequences. (9L)

Convergence in distribution, characteristic function, uniqueness theorem, Levy’s continuity theorem (statement only), CLT for a sequence of independent random variables under Lindeberg’s condition, CLT for iid random variables. (12L)

(45L + 15T)

REFERENCES


202 : STOCHASTIC PROCESSES

Introduction to stochastic processes (sp’s); classification of sp’s according to state space and time domain. Countable state Markov chains (MC’s), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Stationary distribution, classification of states; transient MC; random walk and gambler’s ruin problem; Applications from social, biological and physical sciences. (12L)

Discrete state space continuous time MC: Kolmogorov- Feller differential equations; Poisson process, birth and death process; Applications to queues and storage problems. Wiener process as a limit of random walk; first-passage time and other problems. (8L)

REFERENCES


203: INFERENCE - I

Parametric models, Point estimation, Tests of hypotheses and Interval estimation viewed as decision problems with given loss functions, joint distribution of a sample and induced sampling distribution of a statistic. Likelihood Function, Examples from standard discrete and continuous models (such as Bernoulli, Poisson, Negative Binomial, Normal, exponential, Gamma, Pareto etc.) Plotting Likelihood Functions for these models up to two parameters. (6L)

Information in data about the parameters as variation in Likelihood Function, concept of no information, Sufficiency, Neyman Factorizability Criterion, likelihood Equivalence, Minimal Sufficient Statistic, Exponential families and Pitman Families, Invariance property
of sufficiency under one-one transformation of sample space and parameter space. Fisher Information for one and several parameters models. (7L)


Tests of Hypotheses, Concepts of critical regions, test functions, two kinds of errors, size function, power function, level, MP and UMP test in class of size \( \alpha \) tests, Wald’s SPRT with prescribed errors of two types, Neyman - Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against one sided alternatives and for one sided null against one sided alternatives in one parameter exponential family. Extension of these results to Pitman family when only upper or lower end depends on the parameter and to distributions with MLR property, non-existence of UMP test for simple null against two sided alternatives in one parameter exponential family. Definition of U-statistics and its properties as an estimator of its expectation, Introduction to Standard one sample and two sample non-parametric tests for location. Non-parametric confidence intervals for percentiles. (17L)

Interval estimation, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses. (4L)

REFERENCES


ADDITIONAL REFERENCES


204 : LINEAR MODELS AND REGRESSION ANALYSIS

Gauss-Markov set-up, Normal equations and Least squares estimates, Error and estimation spaces, variances and covariances of least squares estimates, estimation of error variance, estimation with correlated observations, least squares estimates with restriction on parameters, simultaneous estimates of linear parametric functions. (12L)

Tests of hypotheses for one and more than one linear parametric functions, confidence intervals and regions, Analysis of Variance, Power of F-test, Multiple comparison tests due to Tukey and Scheffe, simultaneous confidence intervals. (9L)

Introduction to One-way random effects linear models and estimation of variance components. (4L)

Simple linear regression, multiple regression, fit of polynomials and use of orthogonal polynomials. (4L)

Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers. Remedies. (6L)

Introduction to non-linear models. (4L)

Multicollinearity, Ridge regression and principal component regression, subset selection of explanatory variables, Mallow’s Cp statistic. (6L)

(45L + 20P)

REFERENCES


205 : MULTIVARIATE ANALYSIS

Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector. (3L)

Wishart matrix - its distribution and properties. Distribution of sample generalized variance. Null and non-null distribution of simple correlation coefficient. Null distribution of
partial and multiple correlation coefficient. Distribution of sample regression coefficients. Application in testing and interval estimation. (10L)

Distribution of sample intra-class correlation – coefficient in a random sample from a symmetric multivariate normal distribution. Application in testing and interval estimation. (2L)

Null distribution of Hotelling’s $T^2$ statistic. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. (4L)


Classification and discrimination procedures for discrimination between two multivariate normal populations – sample discriminant function, tests associated with discriminant functions, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations. (10L)

Principal components, Dimension reduction, Canonical variables and canonical correlation - definition, use, estimation and computation. (6L)

(45L + 30P)

REFERENCES


SEMESTER III

301 : INFERENCE - II

Review of convergence in probability and convergence in distribution, Cramer and Slutsky’s Theorems. (4L)

Consistent Estimation of real and vector valued parameter. Invariance of Consistent estimator under continuous transformation, Consistency of estimators by method of moments, and method of percentiles, Mean squared error criterion, Asymptotic relative efficiency, Error probabilities and their rates of convergence, Minimum sample size required to attain given level of accuracy. (8L)

Consistent Asymptotic Normal (CAN) estimator, Invariance of CAN estimator under differentiable transformation, CAN property of estimators obtained by moments and percentiles, CAN estimators obtained by moment and MLE method in one parameter exponential family, Extension to multiparameter exponential family, Examples of consistent but not asymptotically normal estimators from Pitman family. Method of maximum likelihood, CAN estimators for one-parameter Cramer family, Cramer - Huzurbazar theorem, Solution of likelihood equations, Method of scoring, Newton - Raphson and other iterative procedures, Fisher Lower Bound to asymptotic variance, extension to multiparameter case (without proof). Multinomial distribution with cell probabilities depending on a parameter. (12L)

MLE in Pitman Family and Double Exponential distribution, MLE in censored and truncated distributions. (6L)

Likelihood Ratio Test (LRT), Asymptotic distribution of LRT statistic, Wald Test, Rao’s score test, Pearson $\chi^2$ test for Goodness of fit, Bartlett’s Test for homogeneity of variances. Large Sample Tests and confidence intervals based on CAN estimators, Variance stabilizing transformation and large sample tests. Consistency of Large Sample Tests, Asymptotic power of large sample tests. (15L)

(45L + 15T + 10P)

REFERENCES


ADDITIONAL REFERENCES


302: DESIGN AND ANALYSIS OF EXPERIMENTS

Introduction to designed experiments; General block design and its information matrix (C), criteria for connectedness, balance and orthogonality; Intrablock analysis (estimability, best point estimates/interval estimates of estimable linear parametric functions and testing of linear hypotheses); BIBD- recovery of interblock information; Youden design - intrablock analysis. Analysis of covariance in a general Gauss-Markov model, applications to standard designs. (17L)

Fixed, mixed and random effects models; Variance components estimation - study of various methods; Tests for variance components; Missing plot technique - general theory and applications. (8L)

General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2 and 3 factorial experiments in randomized blocks; Complete and partial confounding. Fractional replication for symmetric factorials. Split plot and split block experiments. (10L)

Application areas: Response surface experiments; first order designs and orthogonal designs; clinical trials, longitudinal data, treatment- control designs; Model validation and use of transformation; Tukey’s test for additivity. (10L)

REFERENCES

Myers, R.H..(1971): Response Surface Methodology, Allyn & Bacon

MODULE 1 : PROBABILITY

M.1.1: ADVANCED DISTRIBUTION THEORY

Infinitely divisible distributions; basic properties, canonical representation of the characteristic function due to Levy - Khintchine (statement only). Limit theorems for sums of independent random variables. Characterization of class L. Limit laws for sums of i.i.d random variables; stable laws and canonical representation of their characteristic functions (statement only). Domains of attraction and of partial attraction. (15L)

Order statistics; distributions of median and range. Discrete order statistics and their joint probability mass function. Limit distribution of k-th order statistics. Extreme value laws and their properties; asymptotic joint distribution of extreme order statistics, asymptotic distribution of central order statistic. (5L)

Max-infinite divisible and max-stable distributions. Multivariate extreme value distributions; dependence functions. (5L)

Record values and limit laws for record values. (5L)

Asymptotic distributions of U-statistics, linear functions of order statistics etc. (5L)

(45L+ 15T)

REFERENCES


M.1.2 : FUNCTIONAL ANALYSIS

Metric Spaces, topological notions such as limit points, convergence, closed and open sets, continuity, compactness in metric spaces, isometries and homeomorphisms, complete metric spaces, separable spaces, nowhere-dense sets, the metric spaces $\mathbb{R}(\infty)$ and $\mathbb{C}[0,1]$. (12L)
Normed linear spaces, metric defined by a norm, equivalent norms, Banach spaces and examples (c[a,b], lp, Lp(m) spaces).


Bounded linear transformations, Banach Steinhaus theorem (principle of uniform boundedness), Open mapping theorem, the Hahn Banach theorem and applications.

The dual of a Banach space, (dual of c[a,b], lp, Lp spaces). Riesz representation theorem.

REFERENCES


M.1.3: MARTINGALES

Radon - Nikodym theorem (statement only), conditional expectation, optimality property of conditional expectation in L2.

Martingales in discrete time, Doob's maximal inequality, up crossings inequality. Martingale convergence theorem, reverse martingale convergence theorem, stopping time and interplay with martingales.

Various applications of martingale convergence theorem and reverse martingale convergence theorem (including Levy's theorem on convergence of conditional expectation), proof of strong law of large numbers via martingales. Choquet-Deny theorem, Kolmogorov and Hewitt - Savage zero - one laws.

Introduction to martingales in continuous time, path properties and examples: Brownian motion and Poisson process.
REFERENCES


M.1.4: PROBABILITY MEASURES ON METRIC SPACES

Probability measures on metric spaces: Measures and integrals, tightness, (measure) determining class. Weak convergence of measures: properties of weak convergence and Pontmanteau theorem. Convergence determining class. (10L)

Some special cases: Convergence of probability measures and convergence determining class in the Euclidean space, the circle, the space $\mathbb{R}^\infty$, the product spaces etc. (5L)

Random element of a metric space and its distribution, convergence in distribution of a sequence of random elements - various equivalent criteria for convergence; convergence in probability; weak convergence and mappings. (10L)

Relative compactness and Prohorov’s theorem. Weak convergence and tightness in $C[0,1]$; Wiener measure. Weak convergence and tightness in $D[0,1]$; Donsker’s theorem. (20L)

(45L + 15T)

REFERENCES


M.1.5: INFERERENCE IN STOCHASTIC PROCESSES

Inference in Markov chains, estimation of transition probabilities, testing for order of a Markov chain, estimation of functions of transition probabilities, Parametric models and their goodness of fit. (6L)

Markov sequences, estimation of parameters based on likelihood and conditional least squares, auto-regressive series. (6L)

Statement of martingale strong law of large numbers and CLT for martingales, CAN property of the mle from a general sequence of dependent random variables, Fisher information. Applications to Markov chains and sequences. (6L)

Likelihood of Poisson and other Pure Jump Markov processes from first principles, CAN property of mles , testing for a Poisson process, non-homogeneous processes, Analysis of parametric Pure Jump processes, Birth-Death-Immigration processes, testing goodness of fit of such models (8L)
Diffusion processes and their likelihood, properties of estimators (without proof). (6L)

Branching processes, Inconsistency of mle/moment estimators, Properties of estimators on the non-extinction path, Asymptotic distribution theory (6L)

Elements of semi-parametric and non-parametric analysis, Theory and applications of optimal estimating functions, estimation of transition and stationary density, intensity function of a counting process. (7L)

REFERENCES


M.1.6: APPLIED STOCHASTIC MODELS

Renewal theory: renewal function and its properties, elementary and key renewal theorems, asymptotic normality of the number of renewals, cost/rewards associated with renewals, regenerative processes. Applications (12L)

A review of Markov chains analysis, computing stationary distribution of a large (finite) state-space, applications. (5L)

Poisson process and Pure Jump Markov processes: a review of main results. Birth and Death processes, Applications to Queuing theory, inventory analysis, communication models, population biology and finance, ecology and epidemiology (depending upon the interests of students and the teacher). Computational issues. (14L)

Brownian motion, applications to finance. (8L)
Semi-Markov processes and Markov decision processes: an introduction and applications to various areas. (6L)

REFERENCES


M.1.7: ADVANCED STOCHASTIC PROCESSES


Markov processes- continuous time and continuous state space, time homogeneous Markov processes, Kolmogorov's equations. Diffusion processes with Wiener process and Ornstein-Uhlenbeck process as particular cases. First passage time and reflecting barriers for Wiener process. Relation between Wiener and Uhlenbec processes. (15L)

REFERENCES


MODULE 2: ADVANCED STATISTICAL ANALYSIS

M.2.1: ADVANCED DISTRIBUTION THEORY

Same as M.1.1.

M.2.2: STATISTICAL DECISION THEORY

Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles (conditional Bayes, frequentist), inference problems as decision problems, optimal decision rules. (6L)

Concepts of admissibility and completeness, Bayes rules, admissibility of Bayes rules. (4L)

Supporting and separating hyperplane theorems, minimax theorem of for finite parameter space, minimax estimators of Normal and Poisson means, admissibility of minimax rules. (8L)

Invariant decision rules - location parameter problems, invariance and minimaxity, admissibility of invariant rules, complete class theorem, complete and essentially complete classes in simple estimation and testing situations, estimation of a distribution function. (12L)

Multivariate normal distribution, exponential family of distributions, sufficient statistics, essentially complete classes of rules based on sufficient statistics, complete sufficient statistics. (10L)

Sequential decision rules, Bayes and minimax sequential decision rules, invariant sequential decision problems, sequential tests of a simple hypothesis against a simple alternative, SPRT and stopping rule principle. (5L)

(45L + 15T)

REFERENCES


M.2.3: BAYESIAN INference

Subjective interpretation of probability in terms of fair odds. Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter. Bayes theorem and computation of the posterior distribution. (5L)
Natural Conjugate family of priors for a model. Hyper parameters of a prior from conjugate family. Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension. Enlarging the natural conjugate family by (i) enlarging hyper parameter space (ii) mixtures from conjugate family, choosing an appropriate member of conjugate prior family. Non informative, improper and invariant priors. Jeffrey’s invariant prior. (8L)

Bayesian point estimation : as a prediction problem from posterior distribution. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 - 1 loss. Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk. (6L)

Bayesian interval estimation : Credible intervals. Highest posterior density regions. Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval. (5L)

Bayesian testing of Hypothesis : Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Specification of the Bayes tests in the above cases. Discussion of Lindley’s paradox for testing a point hypothesis for normal mean against the two sided alternative hypothesis. (7L)

Bayesian prediction problem. (2L)

Large sample approximations for the posterior distribution. (2L)

Bayesian calculations for non conjugate priors : (i) Importance sampling, (ii) Obtaining a large sample of parameter values from the posterior distribution using Acceptance - Rejection methods, Markov Chain Monte Carlo methods and other computer simulation methods. (10L)

(45L + 15T)

REFERENCES

Berger, J. O. Statistical Decision Theory and Bayesian Analysis, Springer Verlag.


Leonard T. and Hsu, J. S. J. Bayesian Methods. Cambridge University Press.

ADDITIONAL REFERENCES


Bernando J. M. and Smith, A. F. M. Bayesian Theory, John Wiley and Sons.

Gemerman, D. Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.

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

**M.2.4 : NONPARAMETRIC AND SEMIPARAMETRIC METHODS**

Empirical distribution function, Glivenko Cantelli Theorem, Kolmogorov Goodness of fit test. (6L)


Rank tests, Locally most powerful rank tests, Linear rank statistics and their distributional properties under null hypothesis, Pitman’s asymptotic relative efficiency. (9L)

One sample location problem, sign test and signed rank test, two sample Kolmogorov Smirnov tests. Two sample location and scale problems. Wilcoxon-Mann-Whitney test, normal score test, ARE of various tests based on linear rank statistics. Kruskal-Wallis K sample test. (10L)

Cox’s Proportional Hazards Model, rank test (partial likelihood) for regression coefficients. Concepts of jackknifing method of Quenouille for reducing bias, Bootstrap methods, Confidence intervals. (8L)

(45L + 15P)

**REFERENCES**


**ADDITIONAL REFERENCES**


M.2.5 : ADVANCED MULTIVARIATE ANALYSIS

James-Stein estimator of the mean vector and improved estimation of dispersion matrix of a multivariate normal distribution. (3L)

Distribution of characteristic roots and vectors of Wishart matrices. Distribution of sample canonical correlations, Principal components and their sample variances. Inferences on canonical correlations and principal components. (10L)

Likelihood ratio, union-intersection and other test criteria for testing (1) hypotheses in multivariate linear and generalized linear models (growth curve models), (2) independence of sets of variables, (3) equality of covariance matrices, (4) identity of several normal populations, (5) sphericity, (6) equality of a covariance matrix to a given matrix, (7) equality of a mean vector and a covariance matrix to a given vector and a given matrix. Exact and asymptotic distributions of the test criteria. Associated confidence regions and simultaneous confidence intervals. Unbiasedness and monotonicity of the power function of the tests. (18L)

Invariant multivariate tests. (4L)

Factor analysis, Linear factor models, Estimation of factor loadings, Factor rotation, Estimation of factor scores, Testing goodness of fit. Cluster analysis. (10L)

REFERENCES


Kshirsagar A.M. (1972) Multivariate analysis, Marcel Dekker.


M.2.6 : ADVANCED SAMPLING THEORY

Two-stage sampling with unequal number of second stage units. Issues in stratified sampling : allocation problems involving several study variables, stratum boundary determination problems, Double Sampling. (7L)

Introduction to the unified theory of finite population sampling. (3L)

Horvitz - Thompson Estimator (HTE) of a finite population total/mean, expressions for $V(HTE)$ and its unbiased estimator. Issues in non-negative variance estimation. IPPS schemes of sampling due to Midzuno-Sen, Brewer, Durbin and JNK Rao (sample size 2 only ), Rao-Hartley-Cochran sampling scheme for sample size $n$ with random grouping. (12L)

Issues in small area estimation - synthetic and generalized regression estimators. (6L)

Non-sampling errors and biased responses, randomized responses for variables, errors in surveys, modeling observational errors, estimation of variance components, application to longitudinal studies (repetitive surveys). (8L)

Variance estimation, method of random groups, balanced half samples (IPNSS), Jack-knife method. (5L)

Introduction to superpopulation models. (4L)

(45L + 30P)

REFERENCES


**M.2.7 : TIME SERIES ANALYSIS**

Same as M.6.1.

**M.2.8 : APPLIED REGRESSION ANALYSIS**

Residuals and their analysis, Influential observations, Power transformations for dependent and independent variables. (6L)

Robust and L-1 regression, Estimation of prediction error by cross-validation and bootstrap. (8L)

Non-linear regression models, Different methods of estimation (Least squares, Maximum Likelihood), Asymptotic properties of estimators (8L)

Generalized linear models, Analysis of binary and grouped data by using logistic models, Log-linear models. (8L)

Random and mixed effect models, Maximum likelihood, MINQUE and restricted maximum likelihood estimators of variance components, Best linear unbiased predictors (BLUP), Growth curves. (15L)

(45L + 20P)

**REFERENCES**


M.2.9 : ADVANCED DESIGN & ANALYSIS OF EXPERIMENTS

Finite group and finite field, finite geometry - projective and Euclidean, construction of complete set of mols, lattice designs and their analyses, construction of BIBDs using mols, finite geometry and difference method of lose, inter and intra-block analyses of a BIBD. (10L)

Two -associate PBIB designs - association scheme and intra-block analysis, group divisible designs, dual and linked block designs, resolvable and affine-resolvable designs, general row-column designs - connectedness and intra-block analysis. (10L)

Fractional factorial designs, orthogonal and balanced arrays and their connections with confounded and fractional factorials (6L)

Response surface designs - orthogonality, rotatability and blocking, construction and analysis, method of steepest ascent (6L)

Experiments with mixtures - models, analysis and designs (4L)

Optimum designs - various optimality criteria and their interpretations, regression designs - exact and approximate designs, optimal linear and quadratic regression designs over [-1,1], Equivalence Theorem [ statement and simple applications only ], optimality of BIBD, optimal chemical balance weighing designs, optimality of 2 factorial designs (7L)

Repeated measurements designs [ first order residual effects ] - analysis (2L)

(45L + 20P)

REFERENCES


MODULE 3 : INDUSTRIAL STATISTICS AND OPERATIONS RESEARCH

M.3.1 : STATISTICAL PROCESS AND QUALITY CONTROL

Basic concept of process monitoring and control, process capability and process optimization. (5L)

General theory and review of control charts for attribute and variable data; O.C. and A.R.L. of control charts; control by gauging; Moving average and exponentially weighted moving average charts; Cu-sum charts using V-masks and decision intervals; Economic design of X-bar chart. (10L)

Acceptance sampling plans for attribute inspection; single, double and sequential sampling plans and their properties; Plans for inspection by variables for one-sided and two-sided specifications; Mil Std and IS plans; Continuous sampling plans of Dodge type and Wald-Wolfowitz type and their properties. Bayesian sampling plans. (10L)

Capability indices Cp, Cpk and Cpm; estimation, confidence intervals and tests of hypotheses relating to capability indices for Normally distributed characteristics. (5L)

Use of Design of Experiments in SPC; factorial experiments, fractional factorial designs, construction of such designs and analysis of data. (10L)

Multivariate quality control; use of control ellipsoid and of utility functions. (5L)

(45L+20P)

REFERENCES

Montgomery, D.C. (1985) Introduction to Statistical Quality Control; Wiley
Montgomery, D.C. (1985) Design and Analysis of Experiments; Wiley
Phadke, M.S. (1989) Quality Engineering through Robust Design; Prentice Hall

M.3.2 : PLANNING AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Analysis of single replicate of 2k Full Factorial Experiment, total and artial confounding in 2^k Full Factorial Experiment, Resolution III, IV, and V fractions of 2k experiments.
Statistics

Criteria in selecting factorial designs: Criteria based on the Spectrum of the information matrix-A and D- optimality, criteria based on alias matrix.

Construction of layouts of orthogonal array experiments and associated linear graphs to study some of the main effects and first order interactions of \(2^k\) designs which need not be resolution 3 designs, (designs known as Taguchi designs) with special cases of \(L_8\) and \(L_{16}\).

\(3^k\) Full factorial designs, . Total and partial confounding in \(3k\) Factorial experiments. Construction of Orthogonal array experiments involving three level factors, with special cases of \(L_9\) , and \(L_{18}\).

Roll of Center Composite Designs (CCD) as alternative to \(3k\) designs, rotatability of CCD, Linear and quadratic Response surfaces, contour plots.

Roll of non normality, Box- Cox transformation, Generalized linear models(GLIM), For exponential family of distributions,

REFERENCES


M.3.3 : RELIABILITY

Reliability concepts and measures; components and systems; coherent systems; reliability of coherent systems; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.

Life distributions; reliability function; hazard rate; common life distributions-exponential, Weibull, gamma etc. Estimation of parameters and tests in these models.

Notions of ageing; IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals; loss of memory property of the exponential distribution; closures or these classes under formation of coherent systems, convolutions and mixtures.

Univariate shock models and life distributions arising out of them; bivariate shock models; common bivariate exponential distributions and their properties.
Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation. (5L)

Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process. (4L)

Reliability growth models; probability plotting techniques; Hollander-Proshan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. (5L)

Basic ideas of accelerated life testing. (2L)

REFERENCES


Zacks S. Reliability Theory, Springer.

M.3.4 : STATISTICAL METHODS FOR TOTAL QUALITY MANAGEMENT


Total Quality Management, Process Analysis and Optimization. (8L)

Quality at Design stage, Quality Function Deployment, Failure Mode and Effect Analysis, Conjoint Analysis. System, parameter and tolerance designs. Planning and analysis of fractional factorial experiments. Basic ideas of response surface methodology and contour plots. (15L)

Quality in manufacturing, control charts for attribute and variable characteristics, process adjustments based on control chart evidences. Process capability and performance indices. Evolutionary operations. (10L)

Measuring customer satisfaction, American Customer Satisfaction Index Model. (4L)
REFERENCES


M.3.5 : OPERATIONS RESEARCH I

Definition and scope of Operational research; phases in Operations Research; models and their solutions; decision-making under uncertainty and risk, use of different criteria; sensitivity analysis. (9L)

Review of LP problems; duality theorem; transportation and assignment problems; Non-linear programming-Kuhn Tucker conditions, Wolfe’s and Beale’s algorithms for solving quadratic programming problems. Bellman’s principle of optimality, general formulation, computational methods and application of dynamic programming. (10L)

Analytical structure of inventory problems; EOQ formula of Harris, its sensitivity analysis and extensions allowing quantity discounts and shortages. Multi-item inventory subject to constraints. Models with random demand, the static risk model. P and Q-systems with constant and random lead times. (9L)

Queueing models-specifications and effectiveness measures. Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queue-length and waiting time. M/G/1 queue and Pollazcek Khinchine result. Steady-state solutions of M/Ek/1 and Ek/M/1 queues. Machine interference problem. (9L)

Sequencing and scheduling problems. 2 machine n-job and 3-machine n-job problems with identical machine sequence for all jobs; 2-job n-machine problem with different routings. Branch and bound method for solving travelling salesman problem. (8L)

REFERENCES


**M.3.6 : OPERATIONS RESEARCH II**

Multi-stage decision processes and Dynamic Programming. Integer programming-branch and bound algorithm and cutting plane algorithm. Multi-criterion and goal programming. Stochastic programming; quantile rules, two-stage programming, use of fractional programming. (12L)

Decision-making in the face of competition, two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero-sum games, finding solutions in 2x2, 2xm and mxn games. Non-zero sum games, co-operative and competitive games, equilibrium solutions and their existence in bi-matrix games. Nash equilibrium solution. (11L)

s-S policy for inventory and its derivation in the case of exponential demand; multi-echelon inventory models; models with variable supply and models for perishable items; estimation of EOQ in some simple cases. (6L)

Transient solution of M/M/1 queue; bulk queues (bulk arrival and bulk service); finite queues; queues in tandem; GI/G/1 queue and its solution; simulation of queues. Flows in networks; max-flow min-cut theorem. (8L)

Replacement problems; block and age replacement policies; dynamic programming approach for maintenance problems; replacement of items with long life. Project management; PERT and CPM; probability of project completion, PERT-crashing. (8L)

(45L+24P)

**REFERENCES**

Hadley G. (1964) Non-linear and Dynamic programming; Addison Wesley


Saaty T.L. (1961) Elements of Queueing Theory with Applications; McGraw Hill

Hadley G. and Whitin T.M. (1963) Analysis of Inventory Systems; Prentice Hall


Mckinsey J.C.C. (1952) Introduction to the Theory of Games; McGraw Hill


MODULE 4 : BIOSTATISTICS

M.4.1 : BIOASSAY

Types of biological assays; Direct assays; Ratio estimators, asymptotic distributions; Fieller’s theorem

Regression approaches to estimating dose-response relationships Logit and probit approaches when dose-response curve for standard preparation is unknown; Quantal responses; Methods of estimation of parameters; Estimation of extreme quantiles; Dose allocation schemes; Polychotomous quantal response

Estimation of points on the quantal response function
Sequential procedures
Estimation of safe doses
Bayesian approach to bioassay

(5L + 11L + 5L + 7L + 6L + 5L)

(45L + 18P)

REFERENCES


M.4.2 : STATISTICAL GENETICS

Basic biological concepts in genetics (relevant to this course).
Mendel’s law, Hardy Weinberg equilibrium. Mating tables, estimation of allele frequency (dominant / co-dominant cases). Approach to equilibrium for X-linked gone, Natural selection, mutation, genetic drift, equilibrium when both natural selection and mutation are operative.
Non-random mating, inbreeding, phenotypic assortative mating.
Analysis of family data (a) Relative pair data, I, T; 0 matrices, identity by descent, (b) family data - estimation of segregation ratio under ascertainment bias, (c) Pedigree data - Elston - Stewart algorithm for calculation of likelihooods. Linkage, Estimation of recombination fraction, inheritance of quantitative traits. Models and estimation of parameters.
Sequence similarity, homology and alignment. Algorithms for (a) pairwise sequence alignment, (b) multiple sequence alignment, construction of phylogenetic trees, UPGMA, Neighbor joining, maximum parsimony and maximum likelihood algorithms. (5L)

REFERENCES


ADDITIONAL REFERENCES


M.4.3 - SURVIVAL ANALYSIS

Concepts of time, Order and random Censoring, likelihood in these cases. Life distributions-Exponential Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference (Point estimation, Confidence Intervals, Scores, LR, MLE tests (Rao-Willks-Wald)) for these distributions. (9L)

Life tables, failure rate, mean residual life and their elementary properties. Ageing classes - and their properties, Bathtub Failure rate. (4L)

Estimation of survival function - Acturial Estimator, Kaplan -Meier Estimator, Estimation under the assumption of IFR/DFR. Tests of exponentiality against non-parametric classes-Total time on test, Deshpande test. (10L)

Two sample problem-Gehan test, Log rank test. Mantel-Haenszel test, Tarone - Ware tests. (6L)

Semi-parametric regression for failure rate - Cox’s proportional hazards model with one and several convariates. Rank test for the regression coefficients. (6L)

Competing risks model, parametric and non-parametric inference for this model. (6L)

Multiple decrement life table. (4L)

(45L + 15P)
REFERENCES


M.4.4 : STATISTICAL ECOLOGY

Introduction to Ecology and evolution. (2L)

Population dynamics : single species - Exponential, logistic and Gompertz models, Leslie matrix model for age and stage structured population, Survivorship curves - Constant, monotone and bath tub shaped hazard rates. (10L)

Two species : Lotka - Volterra equations, isoclines, competition and coexistence, predator-pray oscillations. (8L)

Abundance estimation : Capture - recapture, Nearest neighbour, line transect sampling, indirect methods. (10L)

Ecological Diversity : Species abundance curve, Indices of diversity (Simpson’s index, Shannon - Wiener index), Diversity as average rarity. (4L)

Harvesting renewable biological resources - Maximum sustainable yield, tragedy of the commons. (4L)

Game theory in ecology - Evolutionarily stable strategy, its properties, simple games such as Hawk - Dove game. (4L)

Foraging theory : Optimal foraging, diet choice, mean variance trade-off. (3L)

PRACTICALS

Fitting exponential and logistic growth models to data by linearisation method and other methods.

Verification of properties of the discrete logistic model for different values of r the exponential growth rate.
Fitting monotone and bath-tub shaped hazard functions to cohort data.

Simulation study of various abundance estimation methods by the following route: (a) choosing convenient values for parameters (b) generating data sets from such selected configurations (c) obtaining estimates of population density and their sampling distributions.

Writing programs for computing various indices of biological diversity.

REFERENCES


M.4.5 : QUANTITATIVE EPIDEMIOLOGY

Introduction to modern epidemiology, principles of epidemiologic investigation, surveillance and disease monitoring in populations, epidemiologic resources on the Web.

Epidemiologic measures : organizing and presenting epidemiologic data, measures of disease frequency, review of vital statistics and demography, measures of effect and association, causation and causal inference.

Design and analysis of epidemiologic studies : types of studies, case-control studies, cohort studies, cross-over designs, regression models for the estimation of relative risk, meta-analysis, quantitative methods in screening.

Special topics : epidemiology of infectious and chronic diseases, epidemiology of cancer and cancer prevention, environmental epidemiology, molecular and genetic epidemiology.
REFERENCES


M.4.6 : CLINICAL TRIALS

Introduction to clinical trials : the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. (3L)

Data management : data definitions, case report forms, database design, data collection systems for good clinical practice. (2L)

Design of clinical trials : parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial 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 bioequivalence trials. (20L)

Reporting and analysis : analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials. (15L)

Surrogate endpoints : selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data. (2L)

Meta-analysis of clinical trials. (3L)

(45L + 18P)

REFERENCES


E. Marubeni and M. G. Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.
M.4.7 : DEMOGRAPHY

Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan - Deming formula to check completeness of registration data. Adjustment of age data - use of Whipple, Myer and UN indices. Population composition, dependency ratio. (7L)

Measures of fertility; stochastic models for reproduction, distributions of time to first birth, inter-live birth intervals and of number of births (for both homogeneous and non-homogeneous groups of women), estimation of parameters; estimation of parity progression ratios from open birth interval data. (12L)


Stable and quasi-stable populations, intrinsic growth rate. Models for population growth and their fitting to population data. Stochastic models for population growth. (8L)

Stochastic models for migration and for social and occupational mobility based on Markov chains. Estimation of measures of mobility. (6L)

Methods for population projection. Use of Leslie matrix. (6L)

REFERENCES


M.4.8 : GENERALIZED LINEAR MODELS

Logistic and Poisson regression: logit model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters, goodness of fit, analysis of deviance, variable selection, extension to polytomous data, introduction to Poisson regression. (15L)
Log line ar models for two and three dimensional contingency tables: interpretation of parameters, comparison with ANOVA and regression, ML estimation of parameters, likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, partial association, models with quantitative levels.  

Nonparametric regression and generalized linear models: interpolating and smoothing splines for simple regression, use of cross-validation, applications to logistic and Poisson regression introduction to additive models and generalized additive models.

REFERENCES


M.4.9 : APPLIED REGRESSION ANALYSIS

Same as M.2.8.
MODULE 5 : COMPUTATIONAL STATISTICS

M.5.1 COMPUTER-INTENSIVE STATISTICAL METHODS - I

Exploratory data analysis: transforming data, graphical methods of clustering, outliers. (5L)

Linear regression: influential observations and diagnostics, robust methods, collinearity, variable selection. (11L)

Generalized linear models: exponential families and ML estimation, analysis of deviance and variable selection, logistic regression. (10L)

Nonlinear regression: estimation, hypothesis testing, goodness of fit. (6L)

EM algorithm: applications to missing and incomplete data problems, mixture models. (6L)

Smoothing with kernels: density estimation, simple nonparametric regression. (7L)

(45L + 20P)

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

REFERENCES


D.A. Belsley, E. Kuh, and R.E. Welsch (1980); Regression Diagnostics. Wiley.


M.5.2 COMPUTER - INTENSIVE STATISTICAL METHODS-II

Stochastic simulation : generating random variables, simulating multivariate distributions, simulating stochastic processes such as simple queues. (10L)

Variance reduction: importance sampling for integration, control variates and antithetic variables. (10L)
Markov Chain Monte Carlo methods: Gibbs sampling for multivariate simulation, simulated annealing for optimization. (7L)

Simulation based testing: simulating test statistics and power functions, permutation tests. (6L)

Bootstrap methods: resampling paradigms, bias and standard errors, confidence intervals, bootstrapping in regression. (12L)

Jackknife and cross-validation: jackknife in sample surveys, cross-validation for tuning parameters. (5L)

(45L + 20P)

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

REFERENCES

J. Shao and D. Tu (1995); The Jackknife and the Bootstrap. Springer Verlag.

M.5.3 COMPUTER PROGRAMMING

This course is intended to introduce object-oriented computer programming. It assumes prior exposure to programming in languages such as C and/or Fortran. The language of choice here is C++. Should there be previous exposure to C++, Java can be substituted. The course can be followed by the Computer Science course.

Introduction to object-oriented programming concepts and design. (5L)

Programming in C++: data types and operations, functions and parameters, classes, constructors, input/output, control statements such as if-else, switch, for, while and do-while, pointers and references, dynamic allocation, processing of linked lists, arrays and character strings, libraries. (20L)

Introduction to program analysis: simple testing and debugging (5L)

Introduction to Web programming: simple examples in Java and the concept of bytecode. (5L)

(35L + 30P)
Note on practicals/tutorials: As this is a programming course, hand-on practical sessions are important and should be held in conjunction with lectures.

REFERENCES


M.5.4 : KNOWLEDGE DISCOVERY AND DATA MINING

Review of classification methods from multivariate analysis; classification and decision trees. (7L)

Clustering methods from both statistical and data mining viewpoints; vector quantization. (7L)

Unsupervised learning from univariate and multivariate data; dimension reduction and feature selection. (7L)

Supervised learning from moderate to high dimensional input spaces; artificial neural networks and extensions of regression models, regression trees. (10L)

Introduction to databases, including simple relational databases; data warehouses and introduction to online analytical data processing. (8L)

Association rules and prediction; data attributes, applications to electronic commerce. (6L)

(45L + 16P)

Note on practicals/tutorials: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing. Note on prerequisites: This course assumes successful completion of Computer-intensive Statistical Methods I. It can be presented in conjunction with Computer-intensive Statistical Methods II.

REFERENCES


J. Han and M. Kamber (2000). Data Mining; Concepts and Techniques. Morgan Gaufmann.


**M.5.5 : STATISTICAL PATTERN RECOGNITION**

Linear classifiers: linear discriminant function (LDF) for minimum squared error, LDF for binary outputs, perception learning algorithm.  

(12L)

Nearest neighbour decision rules: description, convergence, finite sample considerations, use of branch and bound methods.  

(12L)

Probability of errors: two classes, normal distributions, equal covariance matrix assumptions, Chernoff bounds and Bhattacharyya distance, estimation of probability of error.  

(8L)

Feature selection and extraction: interclass distance measures, discriminant analysis, probabilistic distance measures, principal components.  

(13L)

(45L + 16P)

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

Note on prerequisites: This course assumes successful completion of Computer-intensive Statistical Methods I. It can be presented in conjunction with Computer-intensive Statistical Methods II.

**REFERENCES**


MODULE 6 : ECONOMIC AND FINANCIAL STATISTICS

M.6.1 : TIME SERIES ANALYSIS

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


Detailed study of the stationary processes: (1) moving average (MA), (2) Auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory. Choice of AR and MA periods. Estimation of ARIMA model parameters. Forecasting. Residual analysis and diagnostic checking. Use of computer packages like SPSS.


Use of software package is desirable:
1. Exploratory Analysis
2. Smoothing
3. Numerical exercises on MA and AR models - Forecasting
4. Numerical exercises on ARMA and ARIMA models - Forecasting
5. Numerical exercises on Box-Jenkins models.
6. Residual analysis and diagnostic checking
7. Computations based on Fourier transform
8. Periodogram analysis and interpretation
9. Correlogram analysis and interpretation

REFERENCES


ADDITIONAL REFERENCES


M.6.2 : ECONOMETRICS


Auto correlation, its consequences and tests. Theil BLUS procedure. Estimation and prediction. Multicollinearity problem, its implications and tools for handling the problem. Ridge regression. (10L)

Linear regression with stochastic regressors. Instrumental variable estimation. Errors in variables. Autoregressive linear regression. Distributed lag models. Use of principal components, canonical correlations and discriminant analyses in econometrics. (10L)

Estimation in simultaneous equations model. Recursive systems. 2 SLS Estimators. Limited information estimators, k-class estimators. 3 SLS estimation. Full information maximum likelihood method. Prediction and simultaneous confidence intervals. Monte Carlo studies and simulation. (10L)

LAB WORK (Assignments of 2hrs each)

Use of Software packages is desirable.

1. OLS estimation and prediction in GLM.
2. Use of dummy variables (dummy variable trap) and seasonal adjustment.
3. GLS estimation and prediction.
4. Tests for heteroscedasticity ; pure and mixed estimation.
5. Tests for autocorrelation. BLUS procedure.
7. Industrumenal variable estimation.
8. Estimation with lagged dependent variables.
9. Identification problems - checking rank and order conditions.
10. Estimation in recursive systems.
11. Two SLS estimation.
12. Simulation studies to compare OLS, 2SLS, LISE and FIML methods.

REFERENCES


Intrulligator, MD (1980) : Econometric models - Techniques and applications, Prentice Hall of India.


**M.6.3 : GAME THEORY WITH APPLICATIONS IN ECONOMICS**

Games as decision problems, classification of games. (2L)

Two-person Zero-sum games: normal and extensive forms, maximum criterion, Dominance, mixed strategies, minimax theorem, solutions of 2x2 and 2xm games And of mxn games (using simplex algorithm), equilibrium pairs, uniqueness of Value, games with perfect information. (8L)

Two-person non-zero-sum games : equilibrium pairs and maximin-maximin pairs Finding equilibrium pairs (Swastika method), solution concepts of such games, Proof of Nash’s theorem, co-operative games, bargaining or negotiation set, Maximin bargaining solution, threat bargaining solution. (8L)

N-person games : non-cooperative games, imputations, stable sets, Shapley value Other solution concepts (4L)

Multi-stage games: stochastic games, recursive games, discounted stochastic Games, existence of value, bounds on value iteration, supergames (6L)

Game theory and public economics : allocation of pure public goods, externalities Coalition structures and local public goods, the second best tax Game, Shapley value of public goods games. (6L)

Differential games: existence of value and of saddle-point, solving the Hamilton-Jacobi equation, applications in exhaustible and renewable common property Resources. (6L)

Market games and oligopoly: 1-1 games, N-N games and M-N games, Cournot Equilibrium. (4L)

Bidding and auctions with known valuations and unknown valuations, auction of Two or more objects, horse market auctions (6L)

(50L+13P)
REFERENCES


M.6.4 INVESTMENTS UNDER UNCERTAINTY

Main theme: Risk - Return Trade off. (3L)

Money market, Fixed income, equity, stocks and bonds, Treasury notes, Market indexes, Rates of interest, compound interest, inflation, Risk in a portfolio context, law of one price and arbitrage. (9L)

Risk and risk aversion, mean variance analysis, allocation between risky and risk free portfolios. (6L)

Diversification and portfolio risk, Markovitz portfolio selection, optimal portfolios. (6L)

Capital assets, pricing model, passive strategy, risk premium, Index models and diversification, CAPM and index model. (6L)

Options markets, american and european options, call and put options, open strategies, option like instruments, option valuation. Binomial option pricing, Black-Scholes option valuation, uses of Black-Scholes formula. Futures markets, Mechanics and strategies, Futures prices, expected spot prices. (15L)

(45L + 15T)

REFERENCES


Chapters: 1, 2, 4, 5, 6, 7, 8, 9, 10, 20, 21, 22.

ADDITIONAL REFERENCES


Hull John C. (1993), Options, Futures and Other Derivative Securities. 2nd Ed. Prentice Hall.

M.6.5 : OPTIMIZATION IN ECONOMICS

Production Theory: Production function, diminishing returns, so product curves and production frontiers, Cobb – Douglas production functions. Elasticity of substitutes. Homogeneous and homothetic production functions and their properties. (6L)
Long run and short run average costs. Linear programming for production theory. Indifference curves and their construction and properties, graphic and alternative solutions of the programming problems. (8L)

Comparative statics, endogeneous variables, second order conditions, multivariable models, Slutsky theorem in n variables. Revealed preferences and index numbers. Expenditure theorem, compensated demand function. Cost, revenue and profit functions. (6L)

Theory of the firm : Objectives of the firm, profit maximization, multiple products and inputs, sales maximization, choice of input and output combinations. Market structures, profit maximizing competitive firm, pure monopoly and monopolistic competition, Bilateral and oligopolistic monopoly. reaction curves, oligopolistic pricing. (10L)

Equilibrium and Welfare : Interdependence in the economy, equations of general equilibrium, Walras law, general equilibrium analysis, optimal cash balances, resource allocation, consumer’s and producer’s surplus. Pareto optimality, optimal use of resources in producing given outputs, optimal price system, breakeven constraints, welfare theory, welfare judgements. (15L)

REFERENCES


M.6.6 : ACTUARIAL STATISTICS

Section I - Probability Models and Life Tables

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality. (3L)

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. (6L)

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. (6L)

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations. (3L)
Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications. 

(3L)

Section II - Insurance and Annuities

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions. 

(6L)

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due. 

(6L)

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. 

(6L)

Net premium reserves: Continuous and discrete net premium reserve, reserves on a semicontinuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses.

Claim amount distributions, approximating the individual model, stop-loss insurance. 

(6L)

(45L + 15T)

REFERENCES


Section I - Chapters : 1, 2, 3, 8, 9, 11.

Section II - Chapters : 4, 5, 6, 7, 13, 14.
ADDITIONAL REFERENCES


M.6.7 : OFFICIAL STATISTICS

Introduction to Indian and International statistical systems. Role, function and activities of Central and State statistical organizations. Organization of large scale sample surveys. Role of National Sample Survey Organization. General and special data dissemination systems. (12L)

Population growth in developed and developing countries, evaluation of performance of family welfare programmes, projections of labour force and manpower. Scope and content of population census of India. (12L)

System of collection of Agricultural Statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects. (11L)

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics. (10L)

REFERENCES


Statistical System in India (CSO) 1995.

Principles and accommodation of National Population Censuses, UNESCO.

Panse, V. G., Estimation of Crop Yields (FAO).


Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
UGC MODEL CURRICULUM
STATISTICS

UNIVERSITY GRANTS COMMISSION
New Delhi
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