## Department of Mathematics

ATTENDANCE SHEET -CUM- MINUTES OF BOARD OF STUDIES

Minutes of the meeting of the Board of Studies of Deptt. of Mathematics (Subject) held on 9-4-15 (date) at 11 a.m (time).

PRESENT

| (Name) | | (Signature) |
|---|---|---|
| 1. RAVINDER KUMAR | (Chairperson) | |
| 2. PRAWAL SINHA | (External Expert 1) | |
| 3. ARBIND K Lal | (External Expert 2) | |
| 4. Prof. M. Imdad | (~~Internal~~ External Member) | |
| 5. Gunjan Agarwal | (Internal Member) | |
| 6. Shailendra Pratap Singh | (Internal Member) | |
| 7. Shambhu Sharma | (Internal Member) | |
| 8. Agam Prasad Tyagi | (Internal Member) | |
| 9. Gur Saran | (Internal Member) | |
| 10. Kamal Srivastava | (Internal Member) | |

Proposed changes in the existing system

minutes attached

(Signature of Chairperson)

MINUTES OF THE MEETING OF '**BOARD OF STUDIES**'
DEPARTMENT OF MATHEMATICS

The meeting of the Board of Studies of the Department of Mathematics was held on March 9, 2015. It was attended by the faculty members and three external experts - two from IIT Kanpur and one from AMU.

The syllabus was reviewed with the objective that the students should be well prepared for the NET Examination and for taking up research in the areas offered by the Department. One new programme and four new courses have been proposed. Restructuring has been proposed in nearly fifteen courses as the course contents were observed to be heavy. These proposals have been conveyed to the visiting experts and they have expressed their approval and satisfaction. Summary is given below:

1. **New Programme [For Details See Annexure-I]:** The existing PG Diploma in Industrial Mathematics has been changed to 'Post Graduate Diploma in Big Data, Logistics and Operations Research'. This programme is of 55 credits and comprises 11 courses and 2 projects.
2. **New Courses [For Details See Annexure-II]:**
   - Statistics II for Hons
   - Algebra III (Sylow's Theorem and Inner Product Spaces) for Hons
   - Measure Theory and Lebesgue Integration for M Sc.
   - Galois Theory for M Sc

[With the introduction of new courses in Hons, the credits for each course offered in the Hons will now be at par with the credits in other courses, bringing the total no. of credits to 24. Thus there will be six courses, each of credit 4, per semester - five theory courses and one practical course. ]

3. **Restructuring of Courses [For Details See Annexure-III]:** As suggested by the external experts some courses have been shifted from one programme to the other and the courses on Analysis, Algebra and Statistics have been restructured by shifting some topics to new courses and adjusting the remaining content in five units in view of the observation that the course contents were heavy. Some changes have been proposed in Differential Equations courses also. Details are as follows:
   - Differential Geometry which was taught in MSc is to be shifted to Hons
   - Graph theory, a compulsory course in Hons, will now be offered as an optional course in M Sc
   - Course contents of the Courses on Statistics, Analysis and Algebra have been restructured, by shifting some of the contents to other courses, in view of external experts' comments that the course content for these courses was heavy.
   - Ordinary and Partial Differential Equations will be covered in separate courses in B Sc.
     Mechanics portion from a course on Differential Equations (MAM 401) has been adjusted with the Mechanics course in MSc and a course on Partial Differential Equations in MSc has been merged with the existing courses on Differential Equations in Hons.

**Proposal For**

**Post Graduate Diploma in Big Data, Logistics and Operations Research (PGDBDLOR)**

| | |
|---|---|
| Name of the Programme | **Post Graduate Diploma in Big Data, Logistics and Operations Research (PGDBDLOR)** |
| Offered by | Department of Mathematics |
| Faculty | Faculty of Science |
| Duration of the Programme | One Year |
| Objectives | The objective of this programme is to provide a strong foundation in Statistics, Analytics, Information Systems and Operations Research for effective decision making and building systems based on considerations of data, mining, risk, prescriptive and predictive analysis and the application of decision tools and techniques. |
| Eligibility | Graduate with Honours in Mathematics or Graduate with at least 60% marks in mathematics or Post Graduate with Mathematics as a major subject at degree level or Engineering Graduate. |
| Number of Seats | 10 |
| Admission Criteria | Academic Merit<br>Written Test<br>Interview |

| Code | Title | Credits |
|---|---|---|
| | **Semester I** | |
| DBD101 | Basic Statistics | 4.0 |
| DBD102 | Operations Research (same as MAM303) | 4.0 |
| DBD 103 | Data Mining (same as CSM032) | 4.0 |
| DBD 104 | Data Management, Visualization and R | 4.0 |
| DBD105 | Machine Intelligence (same as CSM042) | 4.0 |
| DBD106 | Computer Laboratory | 6.0 |
| | **Semester Credit** | **26.0** |
| | **Semester II** | |
| DBD 201 | Stochastic Processes and Statistical Inference (same as MAM805) | 4.0 |
| DBD 202 | Advanced Optimization Techniques (same as MAM801) | 4.0 |
| DBD 203 | Modelling and Simulation (same as PEE202) | 4.0 |
| DBD 204 | Big Data Analytics | 4.0 |
| DBD 205 | Logistics, Social Media, Web and Learning Analytics | 4.0 |
| DBD 206 | Project | 6.0 |
| | **Semester Credit** | **26.0** |
| | **Summer** | |
| DBD 001 | Summer Project | 3.0 |
| | **Semester Credit** | **3.0** |
| | **TOTAL PROGRAMME CREDIT** | **55.0** |

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Basic Statistics |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD101 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | New Course |
| 7.1 | Overlap with any UG/PG course of Department/Centre | MAM101 – Probability Theory<br>MAM502 – Statistics II |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | No |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/<br>~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | Students in this introductory-level Statistics courses will learn fundamental concepts in probability and statistics. They will be able to use and apply a variety of specific statistical methods. |

**Course: DBD101, Title: BASIC STATISTICS**

Class: PGDBDLOR, Status of Course: MAJOR COURSE, Approved since session:
Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-0), Min.pds./sem:50

UNIT 1 [10 pds]

Important concepts of probability: Conditional probability, independent events, Bayes' theorem. Random variables: Discrete and continuous, Probability density function, Mathematical expectation.

UNIT 2 [10 pds]

Discrete probability distribution: Binomial, Negative binomial, Poisson. Continuous probability distributions: Uniform, Normal, Normal approximation to the binomial distribution.

UNIT 3 [10 pds]

Simple Correlation, Karl Pearson Coefficient of Correlation, Linear Regression, Regression Coefficients, Properties of Regression Coefficients, Angle between Two Lines of Regression, Coefficient of Determination.

UNIT 4 [10 pds]

Basic idea of Sampling and Sampling Distribution.Hypothesis testing-Null and alternative hypothesis, level of significance, One tailed and two tailed tests, Type I and Type II errors, z-test, t-test, chi square test and F-test.Analysis of Categorical Data: Chi-square Goodness-of-Fit Test. Contingency Analysis: Chi-Square Test of Independence.

UNIT 5 [10 pds]

Non Parametric Test: Runs Test, Mann-Whitney U Test, Wilcoxon Matched-Pairs Signed Rank Test, Kruskal-Wallis Test, Friedman Test, Kolmogorov-Smirnov Test, Spearman's Rank Correlation.

SUGGESTED READING:

Hogg RV, Craig AL: INTRODUCTION TO MATHEMATICAL STATISTICS
Yule UG, Kendall MG: AN INTRODUCTION TO THE THEORY OF STATISTICS
Medhi J: MATHEMATICAL STATISTICS
Kapur&Saxena: MATHEMATICAL STATISTICS
Walpole & Meyers: STATISTICS FOR ENGINEERS AND SCIENTISTS

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Operations Research |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD102 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | |
| 7.1 | Overlap with any UG/PG course of Department/Centre | MAM303 – Operations Research |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | None |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | This course serves as an introduction to the field of Operations Research (OR). The course will cover linear programming in detail and its different applications. The course will also introduce the idea of Game Theory which is applicable to bargaining and negotiation and to Inventory Management. |

**Course: DBD102, Title: OPERATIONS RESEARCH**

Class: PGDBDLOR, Status of Course: MAJOR COURSE, Approved since session:

Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-0), Min.pds./sem:50

**Syllabus same as MAM303**

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Data Mining |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD103 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | |
| 7.1 | Overlap with any UG/PG course of Department/Centre | No |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | CSM032 – Data Mining |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | This course is concerned with finding interesting and useful patterns in data repositories. It aims to provide knowledge on concepts, principles and techniques of data mining. It will also introduce some open source tools for analysing data. |

**Course No. DBD103, Course Title: DATA MINING**

Class: PGDBDLOR. Status of the Course: MAJOR, Approved Since Session:
Credits: 04, Periods (55mts.) per week: 04 (L:4 + T:0 + P:0), Min. periods per semester: 50

**Syllabus same as CSM032**

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Data Management, Visualization and R |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD104 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | New Course |
| 7.1 | Overlap with any UG/PG course of Department/Centre | None |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | - |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | This course will provide an introduction to databases and data visualization. The students will be able to design relational database schemas for various applications, load, transform, and query relational data and use techniques to visualize data. |

**Course No. DBD104, Course Title: DATA MANAGEMENT, VISUALIZATION AND R**
Class: PGDBDLOR. Status of the Course: MAJOR, Approved Since Session:
Credits: 04, Periods (55mts.) per week: 04 (L:4 + T:0 + P:0), Min. periods per semester: 50

UNIT 1
Basic concepts: Database systems, data models, schemas, database systems architecture, ER modelling.
UNIT 2
Relational model: Domains, relations, keys, normalization,relational algebra, calculus.
UNIT 3
SQL: Select statements, displaying data from single and multiple tables, Creating and managing tables, controlling access, advanced subqueries: Multiple column subqueries, Subqueries in FROM clause, Scalar and correlated subqueries.
UNIT 4
Visualization: Value of Visualization, Visual Display of Quantitative Information, Visualization Design, Narrative, Text Visualization, Visual Analytics.
UNIT 5
An Introduction to R, Visualizing and Manipulating Data, Introduction to Programming and Modelling with R.

SUGGESTED READING:
Elmasri&Navathe: FUNDAMENTALS OF DATABASE SYSTEMS, 3/e. Addison Wesley.
Soren V: SQL AND RELATIONAL DATABASE, Galgotia.
E. Tufte:The Visual Display of Quantitative Information (2nd Edition). Graphics Press, 2001
Zuur, Alain, Ieno, Elena N., Meesters, Erik: A Beginners Guide to R, Springer SQL Reference, Oracle Press

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Machine Intelligence |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD105 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | |
| 7.1 | Overlap with any UG/PG course of Department/Centre | None |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | CSM042-Machine Intelligence |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | This course introduces several fundamental concepts and methods for machine learning. The objective is to familiarize the audience with some basic learning algorithms and techniques and their applications, as well as general questions related to analyzing and handling large data sets. |

**Course No. DBD105, Course Title: MACHINE INTELLIGENCE**
Class: PGDBDLOR. Status of the Course: MAJOR, Approved Since Session:
Credits: 04, Periods (55mts.) per week: 04 (L:4 + T:0 + P:0), Min. periods per semester: 50

**Syllabus same as CSM042**

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Computer Laboratory |
| 3 | L-T-P Structure | 0-0-12 |
| 4 | Credits | 6 |
| 5 | Course Number | DBD106 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | None |
| 7.1 | Overlap with any UG/PG course of Department/Centre | |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | To provide hands on experience on tools required for topics in Statistics, Operations Research, Data Management and Machine Intelligence. |

**Course No. DBD106, Course Title: COMPUTER LABORATORY**
Class: PGDBDLOR. Status of the Course: MAJOR, Approved Since Session:
Credits: 06, Periods (55mts.) per week: 06 (L:0 + T:0 + P:6)

Laboratory Based on DBD 101 to DBD 105

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Stochastic Processes and Statistical Inference |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD201 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | |
| 7.1 | Overlap with any UG/PG course of Department/Centre | MAM805- Stochastic Processes and Statistical Inference |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | - |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | The objective of this course is to introduce the student to advanced topics in stochastic processes, theory of estimation, hypothesis testing, reliability theory and design of experiments. |

**Course: DBD201, Title: STOCHASTIC PROC. & STAT. INFERENCE**

Class: PGDBDLOR, Status of Course: MAJOR COURSE, Approved since session:

Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-0), Min.pds./sem:50

**Syllabus same as MAM805**

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Advanced Optimization Techniques |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD202 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | |
| 7.1 | Overlap with any UG/PG course of Department/Centre | MAM801-Advanced Optimization |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | This course will cover advanced topics in operations research and optimization, namely, queueing theory, unconstrained and constrained non-linear programming, dynamic programming and integer programming. |

**Course: DBD202, Title: ADVANCED OPTIMIZATION TECHNIQUES**

Class: PGDBDLOR, Status of Course: MAJOR COURSE, Approved since session:

Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-0), Min.pds./sem:50

**Syllabus same as MAM801**

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Modelling and Simulation |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD203 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | |
| 7.1 | Overlap with any UG/PG course of Department/Centre | |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | PEE202 – Modelling and Simulation |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | The goal is to introduce students to basic simulation methods and tools for modelling and simulation of different types of systems. |

**Course: DBD203, Title:MODELLING AND SIMULATION**

Class: PGDBDLOR, Status of Course: MAJOR COURSE, Approved since session:

Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-0), Min.pds./sem:50

**Syllabus same as PEE202**

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Big Data Analytics |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD204 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | None |
| 7.1 | Overlap with any UG/PG course of Department/Centre | |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | This course will cover the basic concepts of big data and methodologies for analyzing structured and unstructured data. |

**Course: DBD204, Title: BIG DATA ANALYTICS**

Class: PGDBDLOR, Status of Course: MAJOR COURSE, Approved since session:
Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-1), Min.pds./sem:50

UNIT 1
Introduction to big data, Sources of big data, characteristics of big data,importance of big data, big data in enterprise, big data enterprise model,building big data platforms.
UNIT 2
HDFS, MapReduce, relationship between HDFS and MapReduce, Hadoop Implementation, Hadoop clusters
UNIT 3
PIG, SQOOP, HIVE, HBASE, MongoDB.
UNIT 4
Understanding Big Data Analysis with Machine Learning:Supervised, unsupervised machine learning using R and Hadoop, Recommendation algorithms with R and Hadoop
UNIT 5
Linked Big Data, Credit Risk Modelling, Churn Prediction, Business Process AnalyticsFraud Detection and other Real Time Applications.

SUGGESTED READING:
HADOOP: THE DEFINITIVE GUIDE-Tom White- O'Reilly
Bart Baesens, ANALYTICS IN A BIG DATA WORLD: THE ESSENTIAL GUIDE TO DATA SCIENCE AND ITS APPLICATIONS
VigneshPrajapati: BIG DATA ANALYTICS WITH R AND HADOOP

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title (<45 characters) | Introduction to Logistics, Social Media, Web and Learning Analytics |
| 3 | L-T-P Structure | 4-0-0 |
| 4 | Credits | 4 |
| 5 | Course Number | DBD205 |
| 6 | Status (category for program) | (~~Elective~~/Core) |
| 7 | Status vis-à-vis other courses (give course number/title) | None |
| 7.1 | Overlap with any UG/PG course of Department/Centre | |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | |
| 8 | Frequency of offering | ~~Every semester~~/Every alternative semester/ ~~Once in four semester~~/ |
| 9 | Faculty who will teach the course | |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | This course will cover topics in supply chain management, forecasting and Analytics in Social Media, Web and Learning. |

**Course: DBD205, Title: LOGISTICS, SOCIAL MEDIA, WEB AND LEARNING ANALYTICS**

Class: PGDBDLOR, Status of Course: MAJOR COURSE, Approved since session:

Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-1), Min.pds./sem:50

UNIT 1:

Introduction to supply chain management, uncertainty in supply chains, forecasting in managing the supply chain.

UNIT 2:

Demand management, developing and managing the forecasting process, forecasting model selection, forecasting through a product's lifecycle, measuring forecast accuracy.

UNIT 3:

Introduction to learning analytics, assessment, pedagogy and learning analytics, educational data mining, tools.

UNIT 4:

Web, Web analytics and a Web analytics 2.0 framework, measuring user experience, Web metrics and web analytics: On-site web analytics, off-site web analytics, the goal-signal-metric process.

UNIT 5:

Social networks, social network analysis, affiliation, trust and recommendation systems, information propagation, evolution of large networks, introduction to Google social media analytics

SUGGESTED READING:

Sunil Chopra and Peter Meindl: SUPPLY CHAIN MANAGEMENT: STRATEGY, PLANNING AND OPERATION

Martin Christopher: LOGISTICS AND SUPPLY CHAIN MANAGEMENT, Prentice Hall

Avinash Kaushik: WEB ANALYTICS 2.0

Matthew Russel: MINING THE SOCIAL WEB, OReilly.

Larruson and White: LEARNING ANALYTICS-FROM RESEARCH TO PRACTICE

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title(<45 characters) | Statistics II |
| 3 | L-T-P Structure | 4+0+0 |
| 4 | Credits | 4.0 |
| 5 | Course Number | MAM 502 |
| 6 | Status(category for program) | Core |
| 7 | Status vis-à-vis other courses (give course number/title) | - |
| 7.1 | Overlap with any UG/PG course of Department/Centre | Nil |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | Nil |
| 8 | Frequency of offering | Every alternative semester |
| 9 | Faculty who will teach the course | Dr. Agam Prasad Tyagi and Dr. RichaBansal |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | Course content is part of NET Syllabus. |

**Course: MAM502, Title: STATISTICS II**

Class: B.Sc. Honors, Status of Course: MAJOR COURSE, Approved since session:
Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-1), Min.pds./sem:50

UNIT 1

Bivariate Distributions: Joint Probability Distribution, Joint Density Function, Joint Marginal Distributions, Joint Conditional Distributions, Statistical Independence.

UNIT 2

Hypothesis Testing- Null and Alternative Hypothesis, Level of Significance, One Tailed and Two Tailed Tests, Type I and Type II Errors, z-Test, t-Test and F-test.

UNIT 3

Analysis of Categorical Data: Chi-square Goodness-of-Fit Test. Contingency Analysis: Chi-Square Test of Independence.

UNIT 4

Non Parametric Test: Runs Test, Mann-Whitney U Test, Wilcoxon Matched-Pairs Signed Rank Test, Kruskal-Wallis Test, Friedman Test, *Kolmogorov-Smirnov Test, Spearman's Rank Correlation.*

UNIT 5

Multiple Regression Analysis, Partial and Multiple Correlation Coefficients and Related Tests.

SUGGESTED READINGS

MATHEMATICAL STATISTICS: Freund
PROBABILITY & STATISTICS FOR ENGINEERS & SCIENTISTS: Walpole & Myers
PROBABILITY AND STATISTICS FOR ENGINEERS AND SCIENTISTS: Sheldon Ross
BASIC STATISTICS FOR BUSINESS AND ECONOMICS: Lind Marchal Wathen
ESSENTIAL OF STATISTICS FOR BUSINESS AND ECONOMICS: Anderson, Sweeney, Williams
INTRODUCTION TO MATHEMATICAL STATISTICS: Hogg RV, Craig AL

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title(<45 characters) | Algebra III (Sylow's Theorems and Inner Product) |
| 3 | L-T-P Structure | 4+0+0 |
| 4 | Credits | 4 |
| 5 | Course Number | MAM 506 |
| 6 | Status(category for program) | Core |
| 7 | Status vis-à-vis other courses (give course number/title) | - |
| 7.1 | Overlap with any UG/PG course of Department/Centre | Nil |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | Nil |
| 8 | Frequency of offering | Every alternative semester |
| 9 | Faculty who will teach the course | Prof. GunjanAgrawal, Dr. A.B. Joshi and Dr. AntikaThapar |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | Course content is part of NET Syllabus. |

**Course: MAM506, Title: ALGEBRA III (SYLOW'S THEOREMS AND INNER PRODUCT)**

Class: B.Sc. Honors, Status of Course: MAJOR COURSE, Approved since session:
Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-1), Min.pds./sem:50

UNIT I
Conjugacy class, Class Equation, Cauchy's theorem, Sylow's Theorems.
UNIT II
Fundamental Theorem of Finite Abelian Groups, Classification of Groups of Order 2p, pq, etc.
UNIT III
Simple Groups, Tests for Nonsimplicity, Index Theorem, Simplicity of $A_5$.
UNIT IV
Inner Product Spaces, Orthogonal Sets, Orthonormal Basis, Cauchy- Schwarz's Inequality, Gram Schmidt Orthogonalization Process, Orthogonal Complement
UNIT V
Adjoint of a Linear Operator and its Matrix, Normal and Self-Adjoint Operators and Matrices, Unitary and Orthogonal Operators and their Matrices, Their Eigenvalues, Positive Definite Operators and Matrices.

SUGGESTED READING:
ALGEBRA: Michael Artin
ABSTRACT ALGEBRA: D. S. Dummit and R. M. Foote
LINEAR ALGEBRA: S. H. Friedberg, A. J. Insel and L. E. Spence
CONTEMPORARY ABSTRACT ALGEBRA: J. A. Gallian
TOPICS IN ALGEBRA: I. N. Herstein

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title(<45 characters) | Measure Theory & Lebesgue Integration |
| 3 | L-T-P Structure | 4+0+0 |
| 4 | Credits | 4 |
| 5 | Course Number | MAM 701 |
| 6 | Status(category for program) | Core |
| 7 | Status vis-à-vis other courses (give course number/title) | - |
| 7.1 | Overlap with any UG/PG course of Department/Centre | Nil |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | Nil |
| 8 | Frequency of offering | Every alternative semester |
| 9 | Faculty who will teach the course | Prof. Kamal Srivastava and Dr. SoumyaSinha |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | Course content is part of NET Syllabus. |

**Course: MAM701, Title: MEASURE THEORY & LEBESGUE INTEGRATION**

Class: M.Sc., Status of Course: MAJOR COURSE, Approved since session:
Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-1), Min.pds./sem:50

UNIT 1

Algebra and σ algebra of sets, set measures, countably additive set measure, outer measure of set, measurable sets, Lebesgue measure, Lebesgue measurable functions- sum, product and compositions, sequential pointwise limits.

UNIT 2

Lebesgue integration- Lebesgue integral of a bounded measurable function over a set of finite measure, Lebesgue integral of a non negative measurable function.

UNIT 3

General Lebesgue integral, Convergence theorems- Bounded Convergence, Fatou's lemma, monotone convergence and dominated convergence theorems.

UNIT 4

$L^p$ spaces - Holder's and Minkowski's inequalities, $L^p$ space as a metric space, essentially bounded spaces, Convergence in $L^p$ space, Completeness of $L^p$ space.

UNIT 5

Inverse function theorem and Implicit function theorem – Proofs and applications of the theorems.

SUGGESTED READINGS

REAL ANALYSIS: H. N. Royden
MEASURE THEORY AND INTEGRATION: G de Barra

| | | |
|---|---|---|
| 1 | Department/Centre proposing the course | Mathematics |
| 2 | Course Title(<45 characters) | Galois Theory |
| 3 | L-T-P Structure | 4+0+0 |
| 4 | Credits | 4 |
| 5 | Course Number | MAM 911 |
| 6 | Status(category for program) | Core |
| 7 | Status vis-à-vis other courses (give course number/title) | - |
| 7.1 | Overlap with any UG/PG course of Department/Centre | Nil |
| 7.2 | Overlap with any UG/PG course of other Department/Centre | Nil |
| 8 | Frequency of offering | Every alternative semester |
| 9 | Faculty who will teach the course | Prof. GunjanAgrawal and Dr. A.B. Joshi |
| 10 | Will the course require visiting faculty? | No |
| 11 | Course Objectives (about 50 words) Indicating motivation and aims | Course content is part of Net Syllabus. |

**Course: MAM911, Title: GALOIS THEORY**

Class: M.Sc., Status of Course: MAJOR COURSE, Approved since session:
Total Credits:4, Periods(55 mts. each)/week:4(L-4-0+P/S-1), Min.pds./sem:50

UNIT I
Commutator Subgroup, Normal Series, Solvable Group, Solvability of Permutation Groups.
UNIT II
Group of Automorphisms of a Field, Galois Group, Frobenius Automorphism, Galois Group of Splitting Fields of Some Polynomials.
UNIT III
Galois Extension, Intermediate Field, Fundamental Theorem of Galois Theory.
UNIT IV
Solvability by Radicals, Pure Extension, Radical Extension, Solvability of Galois Group.
UNIT V
Solution of a Cubic & Quartic, Non- Solvability of a Quintic, Discriminant, Casus Irreducibilis.

SUGGESTED READING:
ALGEBRA: Michael Artin
ABSTRACT ALGEBRA: D. S. Dummit and R. M. Foote
CONTEMPORARY ABSTRACT ALGEBRA: J. A. Gallian
GALOIS THEORY: Joseph Rotman

**Department of Mathematics, DEI**

**List of Courses: B.Sc. Mathematics**

| Course Code | Courses Title | Credits |
|---|---|---|
| **Semester I** | | |
| MAM 101 | Probability Theory | 3.5 |
| MAM 102 | Discrete Mathematics | 3.5 |
| MAM103 | Seminar & Group Discussion | 1.0 |
| MAM104 | Tutorial | 0.5 |
| MAW101 | Computer Aided Statistical Tech. I (for CSM group only) | 2.0 |
| **Semester II** | | |
| MAM201 | Analysis I (Calculus of one variable) | 3.5 |
| MAM202 | Algebra I (Groups & Rings) | 3.5 |
| MAM203 | Seminar & Group Discussion | 1.0 |
| MAM204 | Tutorial | 0.5 |
| MAW 201 | Computer Aided Statistical Tech. II (for CSM group only) | 2.0 |
| **Semester III** | | |
| MAM 301 | Analysis II (Riemann Integration & Uniform Convergence) | 3.5 |
| MAM 302 | Algebra II (Linear Algebra) | 3.5 |
| MAM 303 | Operations Research | 3.5 |
| MAM 304 | Seminar & Group Discussion | 1.0 |
| MAM 305 | Tutorial | 0.5 |
| **Semester IV** | | |
| MAM 401 | Differential Equations I (Ordinary Differential Equations) | 3.5 |
| MAM 402 | Statistics I | 3.5 |
| MAM 403 | Analysis III (Functions of Several Variables) | 3.5 |
| MAM 404 | Seminar & Group Discussion | 1.5 |
| MAM 405 | Tutorial | 0.5 |
| **Semester V** | | |
| MAM 501 | Analysis IV (Metric Spaces) | 4.0 |
| MAM 502 | Statistics II | 4.0 |
| MAM 503 | Differential Equations II (Partial Differential Equations) | 4.0 |
| MAM 504 | 'C' & Data Structures | 4.0 |
| MAM 505 | Programming Lab | 4.0 |
| MAM 506 | Algebra III (Sylow's Theorems and Inner Product Spaces) | 4.0 |
| **Semester VI** | | |
| MAM 601 | Number Theory | 4.0 |
| MAM 602 | Differential Geometry | 4.0 |
| MAM 603 | Methods of Applied Mathematics | 4.0 |
| MAM 604 | Numerical Analysis | 4.0 |
| MAM 605 | Programming Lab | 4.0 |
| MAM 606 | Complex Analysis | 4.0 |

**List of Courses: M.Sc. Mathematics**

| Course Code | Courses Title | Credits |
|---|---|---|
| **Term I** | | |
| MAM701 | Measure Theory & Lebesgue Integration | 4.0 |
| MAM702 | Topology | 4.0 |
| MAM703 | Theory of Differential Equations | 4.0 |
| MAM705 | Algebra IV (Field Theory) | 4.0 |
| MAM706 | Software Lab | 4.0 |
| Elective Subject I | To be chosen from the list *Elective –I* | 4.0 |
| ***Elective-I*** | | |
| MAM 704 | Mathematical Modelling | 4.0 |
| MAM 904 | Fuzzy sets and Systems | 4.0 |
| **Term II** | | |
| MAM801 | Advanced Optimization Techniques | 4.0 |
| MAM802 | Algebra V (Canonical Forms) | 4.0 |
| MAM804 | Functional Analysis | 4.0 |
| MAM805 | Stochastic Proc. & Stat. Inference | 4.0 |
| MAM806 | Software Lab | 4.0 |
| Elective Subject II | To be chosen from the list *Elective –II* | 4.0 |
| ***Elective-II*** | | |
| MAM803 | Fluid Dynamics | 4.0 |
| MAM812 | Graph Theory | 4.0 |
| **Term III (Summer Term)** | | |
| MAM001 | Research Methodology | 4.0 |
| MAM002 | Pre-Dissertation | 4.0 |
| **Term IV** | | |
| MAM901 | Dissertation | 12.0 |
| MAM905 | Analytical Mechanics | 4.0 |
| MAM911 | Galois Theory | 4.0 |



806

**List of Courses: M.Sc. Mathematics with Specialization in Computer Applications**

| Course Code | Course Title | Credits |
|---|---|---|
| **Term I** | | |
| MAM 701 | Measure Theory & Lebesgue Integration | 4 |
| MAM 702 | Topology | 4 |
| MAM 703 | Theory of Differential Equations | 4 |
| MAM 706 | Software Lab | 4 |
| MAM 707 | Computer Systems Architecture | 4 |
| MAM 708 | Database Management Systems | 4 |
| **Term II** | | |
| MAM 801 | Advanced Optimization Techniques | 4 |
| MAM 805 | Stochastic Proc. & Stat. Inference | 4 |
| MAM 806 | Software Lab | 4 |
| MAM 807 | Internet Technologies | 4 |
| MAM 808 | Software Engineering | 4 |
| Elective Subject I | To be chosen from the list *Elective –I* | 4 |
| ***Elective –I*** | | |
| MAM 809 | Cryptography & Security | 4 |
| MAM 810 | Intelligent Information Processing(same as PHM 960) | 4 |
| MAM 811 | Advanced Algorithms | 4 |
| MAM 812 | Graph Theory | 4 |
| **Term III(summer term)** | | |
| MAM 001 | Research Methodology | 4 |
| MAM 002 | Pre –Dissertation | 4 |
| **Term IV** | | |
| MAM 901 | Dissertation | 12 |
| Elective Subject II | To be chosen from the list *Elective –II* | 4 |
| Elective Subject III | To be chosen from the list *Elective –II* | 4 |
| ***Elective –II*** | | |
| MAM904 | Fuzzy Sets & Systems | 4 |
| MAM905 | Analytical Mechanics | 4 |
| MAM908 | Computer Networks | 4 |
| MAM909 | Computer Graphics | 4 |
| MAM910 | Automata Theory & Formal Languages | 4 |

**Proposed List of Courses: M.Phil. Mathematics**

| Course Code | Course Title | Credits |
|---|---|---|
| **Term I** | | |
| MAM 951 | Dissertation I | 8 |
| MAM 953 | Self Study Course | 4 |
| MAM 954 | Scientific Computing | 4 |
| MAM 955 | Special Topics in Mathematics | 4 |
| **Term II** | | |
| MAM 952 | Dissertation II | 16 |

**SUMMARY OF CHANGES PROPOSED AND JUSTIFICATION**

| EXISTING | PROPOSED | REMARKS/ JUSTIFICATION |
|---|---|---|
| MAM 101 PROBABILITY THEORY | UNIT 1<br>Important concepts of probability, Mathematical Probability, Statistical Probability, Axiomatic Approach to Probability, Addition Theorem of Probability, Conditional Probability, Multiplication Theorem of Probability, Independent Events, Multiplication Theorem of Probability for independent events, Pairwise Independent Events, Total Probability Rule, Bayes' Theorem.<br>UNIT 2<br>Random Variables: Discrete and Continuous, Probability mass function, Probability Density Function, Distribution Function for Discrete and Continuous Random Variables. Mathematical Expectation or Expected Value of a Random Variable, Expected Value of Function of Random Variable, Properties of Expectation, Mean, Variance and Covariance of a random variable, Means and Variances of Linear Combination of Random Variables.<br>UNIT 3<br>Discrete Probability Distributions: Probability Function and Properties of Bernaulli, Binomial, Poisson, Negative Binomial, Geometric and Hypergeometric distributions. Solving Discrete Distribution based Problems by Formula. Poisson Distribution as a limiting case of Binomial Distribution.<br>UNIT 4<br>Continuous Probability Distributions: Probability Density Functions of Rectangular (Uniform) Distribution, Normal Distribution, Standard Normal Distribution. Characteristics of Normal Distribution, Area Under the Normal Curve, Applications of Normal Distribution, Normal Distribution as a Limiting Form of Binomial Distribution.<br>UNIT 5<br>Moments, Moment Generating Function and Moment Generating Function of Bernaulli, Binomial, Poisson, Negative Binomial, Geometric, Hypergeometric, Rectangular Distribution and Normal Distributions | Some topics from Unit 1 have been deleted as these are covered at Intermediate level. Remaining Topics have been included in new Unit 5.<br>As suggested by the members of BOS meeting, course contents were heavy. So the contents of remaining Units have been restructured to maintain the continuity and to teach the topics in depth. |
| MAM 102 DISCRETE MATHEMATICS | UNIT1<br>Mathematical Logic: Propositions, Connectives, propositional formulae, truth tables, equivalence of formulas, tautological implications, normal forms: disjunctive and conjunctive; Theory of inference for propositional calculus; Predicate calculus: predicates, variables and quantifiers, free and bound variables, universe of discourse, nested quantifiers, rules of inference for predicate calculus. Proof methods.<br>UNIT2<br>Review of basic concepts in set theory: Russel's Paradox, Arbitrary Union, Arbitrary Intersection, Equivalence relation, Partition of a Set, Composition and inverse of a Function; Finite sets, Countable and uncountable sets, Axiom of choice, Partially Ordered Set, Ordered Set, Dictionary Order Relation, Upper Bound/ Lower Bound, Maximal/Minimal Element, Supremum, Infimum, Lattice, Zorn's Lemma, Well ordering principle.<br>UNIT3<br>Principles of Mathematical induction, Division Algorithm, Prime Numbers, Euclid's lemma, Greatest Common Divisor, Euclidean Algorithm, Fundamental Theorem of Arithmetic, Congruence, | As suggested in BOS meeting, course content of Unit1, Unit2 and Unit3 has been redefined and some new topics in Unit1, Unit2 and Unit3 , which were being left out and were also important from the point of view of competitive are included. |

| | | |
|---|---|---|
| | Properties of Congruence, Integers Modulo n.<br>UNIT4<br>Combinatorics: Fundamental laws of counting, pigeonhole principle, permutations, combinations, binomial theorem, multinomial theorem, principle of exclusion and inclusion, derangements, permutations with forbidden positions.<br>UNIT5<br>Discrete numeric functions, Generating functions, Recurrence relations. | |
| MAW 101 COMPUTER AIDED STATISTICAL TECH. I (for CSM group only) | Introduction to Computers, Introduction to MATLAB/SYSTAT, Graphical Representation of Data, Measures of Central Tendency and Dispersion through MATLAB/SYSTAT. | |
| MAM 201 ANALYSIS I (Calculus of one variable) | UNIT 1<br>Real Number System and the Completeness Property, Intervals, Open Sets as Union of Open Intervals, Closed Sets, Archimedean Property of Real Numbers, Rational Density Theorem, Irrational Density Theorem, Sequences in R, Limit of a Sequence, Limit Superior and Limit Inferior of a Sequence, Monotone Sequences, Cauchy Sequence.<br>UNIT 2<br>Convergence of Infinite Series, Alternating Series, Absolute Convergence, Conditional Convergence, Tests for Convergence of Series, Decimal, Binary and Ternary Representation of Real Numbers, Uncountability of Real Numbers.<br>UNIT 3<br>Limit of a Function, Continuous Function, Algebra of Continuous Functions, Types of Discontinuities, Limits at Infinity, Infinite Limits, Asymptotes, Bounded Function, Intermediate Value Theorem, Extreme Value Theorem.<br>UNIT 4<br>Derivative of a Real Function, Algebra of Differentiable Functions, Chain Rule, Implicit Differentiation, Curves in Plane, Parametric Equations of a Curve, Slope of a Curve, Tangent, Vertical Tangent, Normal, Higher Order Derivative, Leibnitz Rule, Mean Value Theorem, Rolle's Theorem, Intermediate Value Theorem for Derivatives.<br>UNIT 5<br>Indeterminate Forms, Applications of Derivatives, Local Maxima Minima, Increasing and Decreasing Functions, Concavity, Point of Inflection, Asymptotes, Graphing in Cartesian Coordinates, Polar Coordinates, Polar Equations, Graphing in Polar Coordinates. | UNIT 1 of MAM 301 shifted to MAM 101 and distributed in Units 1 and 2. Unit 5 of MAM 101shifted to MAM 301 in order to strengthen the basic concepts of real numbers and other related topics in Analysis. New topics added in Unit 2. Units 3, 4 and 5 are earlier UNITS 2, 3 and 4 with minor restructuring |
| MAM 202 ALGEBRA I (Groups and Rings) | UNIT 1<br>Group, Cyclic Group, Order of an Element, Subgroup, Subgroup Generated by a Subset, Internal Direct Product of Subgroups, Centre, Centralizer, External Direct Product of Groups, Matrix groups-GL(n, R), SL(n, R), Quaternion Group, Dihedral Group.<br>UNIT 2<br>Permutation Group, Alternating Group, Fundamental Theorem of Cyclic Groups, Cosets, Lagrange's Theorem, Normal Subgroup, Quotient Group.<br>UNIT 3<br>Group Homomorphism, Group Isomorphism, Inner Automorphism, Group Isomorphism Theorems, Group of Automorphisms, Cayley's Theorem, Aut ($Z_n$). | As observed in the BOS meeting, Course Contents were heavy. So the contents have been restructured and some of the contents shifted to MAM 506. |

| | | |
|---|---|---|
| | UNIT 4<br>Ring, Polynomial Ring as an Example of Rings, Subring, Integral Domain, Field, Characteristic, Ideal, Quotient Ring, Prime Ideal, Maximal Ideal.<br>UNIT 5<br>Ring Homomorphism, Ring Isomorphism, Ring Isomorphism Theorems, Subfield, Subfield Generated by a Subset, Prime Subfield, Field of Quotients.<br><br>SUGGESTED READING:<br>ABSTRACT ALGEBRA: D. S. Dummit and R. M. Foote<br>CONTEMPORARY ABSTRACT ALGEBRA: J. A. Gallian<br>TOPICS IN ALGEBRA: I. N. Herstein | |
| MAW 201 COMPUTER AIDED STATISTICAL TECH. II (for CSM group only) | Laboratory based on the Course MAM 201, using SYSTAT/MATLAB/ EXCEL. | |
| MAM 301 ANALYSIS II (Riemann Integration & Uniform Convergence) | UNIT 1<br>Riemann Integration: Partition of a Set, Step Function, Riemann Integral of a Step Function, Upper Riemann Integral, Lower Riemann Integral, Riemann Integral of a Bounded Function, Mean Value Theorem of Integral Calculus, Fundamental Theorem of Calculus<br>UNIT 2<br>Elementary Functions, Natural Logarithms, Exponential Function, Inverse Function, Trigonometric and Inverse-Trigonometric Function, Hyperbolic Functions, their Derivatives.<br>UNIT 3<br>Techniques of Integration, Applications of Integration: Area, Volume, Surface Area, Length of an Arc, Improper Integrals.<br>UNIT 4<br>Limit Superior and Limit inferior of sequence of functions, Power Series, Radius and interval of convergence, Circular, exponential functions etc as examples, Taylor's series, Uniform Convergence and Pointwise Convergence of Sequence of Functions, Cauchy Criterion for Uniform Convergence, Tests for Uniform Convergence.<br>UNIT 5<br>Uniform Convergence and Pointwise Convergence of Series of Functions, Weierstrass M test, Dini's theorem and other tests for Uniform convergence of series. Consequences of Uniform convergence of series and sequences. | UNIT 3 on Riemann Integartion renamed as **UNIT 1**. UNIT 5 of MAM 101 shifted to **UNIT 2** of MAM 301 as it will be better understood after Riemann Integration. UNIT 4 on Techniques of Integration now shifted to **UNIT 3.** UNIT 2 on Uniform Convergence is now distributed in **UNIT 4** and **UNIT 5** with the aim to provide more strength to these topics. This has been done as per the discussions during BOS meeting. Riemann-Stieltjes integral was considered to be less important and is removed now. |
| MAM 302 ALGEBRA II (Linear Algebra) | UNIT 1<br>Vector Space, Subspaces, Sum of Subspaces, Linear Independence, Basis and Dimension, Co-ordinate, Change in Coordinates with Change in Basis, The Row Space and Column Space, Rank of a Matrix.<br>UNIT 2<br>Linear Transformation, Isomorphism, Algebra of Linear Transformations, Rank and Nullity of Linear Transformation, Rank and Nullity Theorem, Matrix Representation of a Linear Transformation, Composition of Linear Transformations and Matrix Multiplication.<br>UNIT 3 | As observed in the BOS meeting, Course Contents were heavy. So the contents have been restructured. Unit III shifted to MAM 506. Unit V shifted to MAM 802. Unit IV has all new topics and Theory of System of Linear Equations included in |

| | | |
|---|---|---|
| | Change of Co-ordinate Matrix, Similarity of Matrices and Linear Transformation, Dual Space and its Basis, Elementary Matrices, Row Echelon Form of Matrices.<br>UNIT 4<br>Matrices in Block Form, Determinant of a Matrix over a Ring, Existence and Uniqueness of Determinant, Inverse of a Matrix, Determinant of a Linear Transformation, Right Handed Co-ordinate System, Application to Area and Volume, Determinant of Matrices in Block Form.<br>UNIT 5<br>Theory of System of Linear Equations, Eigen Values and Eigen Vectors of a Linear Transformation and a Matrix, Eigen Space, Characteristic Polynomial, Characteristic Polynomial and Trace, Applications of Cayley-Hamilton Theorem.<br><br>SUGGESTED READING:<br>LINEAR ALGEBRA: K. Hoffman and R. Kunze<br>LINEAR ALGEBRA: S. H. Friedberg, A. J. Insel and L. E. Spence | Unit V. |
| MAM 303 OPERATIONS RESEARCH | UNIT 1<br>Introduction to general linear programming problems, Geometrical and algebraic analysis of models/solutions. Definitions and Theorems, solution of LPP-graphical, simplex method.<br>UNIT 2<br>Two-phases of simplex, Big-M method. Concept of Duality: Weak Duality Theorem, Basic Duality Theorem, Fundamental Theorem on Duality, Complementary Slackness Theorem, Dual-simplex method.<br>UNIT 3<br>Post-optimality analysis: Variation in cost vector, resource vector, addition/deletion of constraints/variables. Transportation, Assignment and Travelling-salesman problems.<br>UNIT 4<br>Game Theory: Definitions, Maximin and Minimax principles, Two-person zero-sum game, Games with saddle point (Pure strategy), Games without saddle points (Mixed strategy), Graphical method, Dominance principle.<br>UNIT 5<br>Inventory Problem: Introduction, Economic Order Quantity, Deterministic inventory with no shortages: The basic EOQ model, EOQ with several production runs of unequal lengths, EOQ with fixed (finite) production (replenishment). Deterministic inventory with shortages, Stochastic inventory models. | As suggested in BOS meeting, course content of MAM402 and MAM801 is restructured in accordance with the syllabus of new programme Post Graduate Diploma in Big Data, Logistics and Operations Research (PGDBDLOR) proposed by Department of Mathematics. |
| MAM 401 DIFFERENTIAL EQUATIONS I (Ordinary Differential Equations) | UNIT 1<br>Equations of first order and first degree - exact equations. Elementary applications - Newton's law of cooling, orthogonal trajectories. Linear equations with constant coefficients, complementary function, auxilliary equation - distinct roots, repeated roots, imaginary or complex roots, particular integral-the operator D, methods of finding PI of variation of parameters.<br>UNIT 2<br>Equations of first order but not of first degree, simultaneous equations dx/P = dy/Q = dz/R, use of multipliers, total differential equations, necessary and sufficient conditions that an equation of the type P dx + Q dy + R dz be integrable, methods of solution.<br>UNIT 3 | As suggested in the BOS meeting, Units III, IV and V have been deleted. Units I and II compressed in Unit I. Units II to V comprise the content of Units I to III of MAM 503. |

| | | |
|---|---|---|
| | Solution in series, linear equations and power series, convergence of power series, ordinary and singular points, validity of the solutions near an ordinary point, solutions near an ordinary point, regular singular point, the indicial equation, form and validity of the solutions near a regular singluar point, indicial equations with difference of roots nonintegral, indicial equations with equal roots with difference of roots a positive integer, non-logarithmic and logarithmic cases.<br>UNIT 4<br>Bessel's equations, Legendre's equations, their recurrence relations, orthogonal properties and generating functions.<br>UNIT 5<br>Hypergeometric equation, Laguerre polynomial, Hermite polynomial and their properties.<br><br>SUGGESTED READINGS:<br>Braun M: DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS<br>ED Rainville & PE Bedient: ELEMENTARY DIFFERENTIAL EQUATIONS<br>Yoshida: DIFFERENTIAL EQUATIONS AND APPLICATION | |
| MAM 402 STATISTICS-I | UNIT I<br>Simple Correlation, Karl Pearson Coefficient of Correlation, Linear Regression, Regression Coefficients, Properties of Regression Coefficients, Angle between Two Lines of Regression, Coefficient of Determination.<br>UNIT 2<br>Introduction to Sampling: Reasons for Sampling, Reasons for taking a census, Frame, Random Versus Non Random Sampling. Random Sampling Techniques: Simple Random Sampling, Stratified Random Sampling, Systematic Sampling, Cluster or Area Sampling. Non-random Sampling: Convenience Sampling, Judgment Sampling, Quota Sampling, Snowball Sampling.<br>UNIT 3<br>Sampling Distributions: Statistic and Parameter, Sampling Distribution of Means, Sampling Distribution of Proportion, Sampling Distribution of Difference of Means, Sampling Distribution of Difference of Proportion, Working Problems Based on the Sampling Distributions of Statistics.<br>UNIT 4<br>Probability inequalities (Chebychev's Inequality, Morkov's, Jensen), Modes of Convergence, Weak and Strong Laws of Large Numbers, Bernaulli's Law of Large Numbers, Central Limit Theorem (i.i.d. case)<br>UNIT 5<br>Estimation: Point Estimation, Properties of Point Estimate, Interval Estimation. Estimating the Mean for single sample, Standard Error of Point Estimate, Estimating the Difference Between Two Means for Two Samples, Estimating the Proportion for single sample, Estimating the Difference Between Two Means for Two Samples, Estimating Population Variance, and Sample Size and working problems based on them.<br><br>SUGGESTED READING:<br>MATHEMATICAL STATISTICS: Freund<br>PROBABILITY & STATISTICS FOR ENGINEERS & SCIENTISTS: Walpole & Myers<br>PROBABILITY AND STATISTICS FOR ENGINEERS AND | As suggested by the members of BOS meeting, course contents were heavy, so the contents have been restructured to maintain the continuity and to teach the topics in depth. Further some of the contents shifted to MAM 606 due to same reason. |

| | | |
|---|---|---|
| | SCIENTISTS: Sheldon Ross<br>BASIC STATISTICS FOR BUSINESS AND ECONOMICS: Lind Marchal Wathen<br>ESSENTIAL OF STATISTICS FOR BUSINESS AND ECONOMICS: Anderson, Sweeney, Williams<br>INTRODUCTION TO MATHEMATICAL STATISTICS: Hogg RV, Craig AL | |
| MAM 403<br>ANALYSIS III<br>(Functions of Several Variables) | UNIT 1<br>Sequences in $R^n$ , Limit and Continuity of Maps from $R^n$ to R, R to $R^n$ and $R^m$ to $R^n$, Related Sum and Product Theorems, Continuity of Composition, Differentiation of Maps from $R^n$ to R, R to $R^n$ and $R^m$ to $R^n$, Total Derivative, Related Results.<br>UNIT 2<br>Partial Derivatives, Jacobian Matrix, Directional Derivative, Chain Rule, Mean Value Theorem, Taylor's Formula, Linear and Quadratic Approximation, Local Maxima, Local Minima, Lagrange Multipliers.<br>UNIT 3<br>Multiple Integrals: Double Integrals, Double Integrals as Volumes, Fubini's Theorem, Changing to Polar Coordinates, Triple Integration in Cartesian, Cylindrical and Spherical Coordinates.<br>UNIT 4<br>Substitution in Multiple Integrals, Curves in Space, Line Integrals, Work, Circulation, Flux, Applications of Green's Theorem.<br>UNIT 5<br>Surface Integrals, Surface Area, Divergence and Curl Operations, Applications of Gauss Divergence Theorem and Stoke's Theorem. | UNIT 1, 2 and 3 have been compressed to UNITS 1 and 2. Added Sequences in $R^n$ to strengthen the concepts of limit and continuity.<br>UNITS 4 and 5 redefined as UNITS 3, 4 and 5 |
| MAM 501<br>ANALYSIS IV<br>(Metric Spaces) | UNIT 1<br>Definition and examples of metric spaces, Open balls and open sets, interior points and interior of a set, limit points, cluster points, boundary points, Dense sets, boundary of a set.<br>UNIT 2<br>Convergent sequences, Cauchy sequences, Complete metric spaces, examples, Baire Category theorem, Cantor intersection theorem, Banach Contraction principle.<br>UNIT 3<br>Limit, Continuity, equivalent definitions, uniform continuity, applications of Weierstrass approximation theorem.<br>UNIT 4<br>Compactness: Compact Metric Spaces, Sequential Compactness, Limit Point Compactness, Heine-Borel Theorem, Uniform Continuity and compactness.<br>UNIT 5<br>Connectedness: Connected spaces, applications of intermediate value theorem to existence of nth roots and solution of polynomials. | This course is now completely dedicated to metric spaces as it is an important part of NET syllabus. The measure theory part has been shifted to a new course in MSc. This has been done as per the discussions at BOS meeting. |
| MAM 502<br>STATISTICS II | UNIT 1<br>Bivariate Distributions: Joint Probability Distribution, Joint Density Function, Joint Marginal Distributions, Joint Conditional Distributions, Statistical Independence.<br>UNIT 2<br>Hypothesis Testing- Null and Alternative Hypothesis, Level of Significance, One Tailed and Two Tailed Tests, Type I and Type II Errors, z-Test, t-Test and F-test. | As suggested by the members of BOS, a new course has been introduced in VI sem to maintain the continuity and to teach the subject in depth as the course is |

| | | |
|---|---|---|
| | UNIT 3<br>Analysis of Categorical Data: Chi-square Goodness-of-Fit Test. Contingency Analysis: Chi-Square Test of Independence.<br>UNIT 4<br>Non Parametric Test: Runs Test, Mann-Whitney U Test, Wilcoxon Matched-Pairs Signed Rank Test, Kruskal-Wallis Test, Friedman Test, *Kolmogorov-Smirnov Test, Spearman's Rank Correlation.*<br>UNIT 5<br>Multiple Regression Analysis, Partial and Multiple Correlation Coefficients and Related Tests.<br><br>SUGGESTED READING:<br>MATHEMATICAL STATISTICS: Freund<br>PROBABILITY & STATISTICS FOR ENGINEERS & SCIENTISTS: Walpole & Myers<br>PROBABILITY AND STATISTICS FOR ENGINEERS AND SCIENTISTS: Sheldon Ross<br>BASIC STATISTICS FOR BUSINESS AND ECONOMICS: Lind Marchal Wathen<br>ESSENTIAL OF STATISTICS FOR BUSINESS AND ECONOMICS: Anderson, Sweeney, Williams<br>INTRODUCTION TO MATHEMATICAL STATISTICS: Hogg RV, Craig AL | significant from point of view of the National Eligibility Test (NET). |
| MAM 503 DIFFERENTIAL EQUATIONS II (Partial Differential Equations) | UNIT 1<br>Linear Partial Differential Equations: Lagrange's method, Working rule for solving Pp+Qq = R by Lagrange's method, geometrical description of Pp+Qq = R. Non-linear Partial Differential Equations of Order 1: Complete Integral, particular integral, singular integral and general integral. Standard form I: only p and q present, standard form II: z = px + qy + f(p,q), standard form III: only p q and z present, standard form IV: equations of the form $f_1(x,p) = f_2(y,p)$, Charpit method, Jacobi method. Cauchy's problem for first order PDE's.<br>UNIT 2<br>Second order PDE's, Classification of second order PDE's, Canonical forms for Hyperbolic, Parabolic and Elliptic equations.<br>UNIT 3<br>Elliptic Differential Equations- Derivation of Laplace equation, solution of Laplace equation in polar, cylindrical and spherical coordinates, separation of variable method, Neumann and Dirichlet problems.<br>UNIT 4<br>Parabolic Differential Equations- occurrence and derivation of Diffusion equation, boundary conditions, solution of Diffusion Equation in polar, cylindrical and spherical coordinates, boundary value problems.<br>UNIT 5<br>Hyperbolic Differential Equations- occurrence and derivation of Wave equation, Solution of wave equation in polar, cylindrical and spherical coordinates, D'Alembert's Solution, Vibrating String-Variable separable solution, boundary and initial value problems for two-dimensional wave equations- method of eigen function.<br><br>SUGGESTED READINGS:<br>K Shankara Rao: INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS<br>IN Sneddon: ELEMENTS OF PARTIAL DIFFERENTIAL | As suggested in the BOS meeting, Units I to III shifted to MAM 401. Unit IV renamed as Unit I. Unit V shifted to MAM 603. Units II, III, IV and V are Units I, II, III and IV resoectively of MAM 705. |

| | | |
|---|---|---|
| | EQUATIONS<br>F John: PARTIAL DIFFERENTIAL EQUATIONS | |
| MAM 506 ALGEBRA III (Sylow's Theorems & Inner Product) | UNIT I<br>Conjugacy class, Class Equation, Cauchy's theorem, Sylow's Theorems.<br>UNIT II<br>Fundamental Theorem of Finite Abelian Groups, Classification of Groups of Order 2p, pq, etc.<br>UNIT III<br>Simple Groups, Tests for Nonsimplicity, Index Theorem, Simplicity of $A_5$.<br>UNIT IV<br>Inner Product Spaces, Orthogonal Sets, Orthonormal Basis, Cauchy- Schwarz's Inequality, Gram Schmidt Orthogonalization Process, Orthogonal Complement<br>UNIT V<br>Adjoint of a Linear Operator and its Matrix, Normal and Self-Adjoint Operators and Matrices, Unitary and Orthogonal Operators and their Matrices, Their Eigenvalues, Positive Definite Operators and Matrices.<br><br>SUGGESTED READING:<br>ALGEBRA: Michael Artin<br>ABSTRACT ALGEBRA: D. S. Dummit and R. M. Foote<br>LINEAR ALGEBRA: S. H. Friedberg, A. J. Insel and L. E. Spence<br>CONTEMPORARY ABSTRACT ALGEBRA: J. A. Gallian<br>TOPICS IN ALGEBRA: I. N. Herstein<br>LINEAR ALGEBRA: K. Hoffman and R. Kunze | A new course introduced to cover important topics from NET syllabus in due detail. |
| MAM 602 DIFFERENTIAL GEOMETRY | UNIT 1<br>Curves in Space, Arc length, Velocity, Acceleration, Curvature and Torsion, Frenet-Serret formula, Osculating Plane, Normal Plane, Tangent Plane.<br>UNIT 2<br>Spherical Curves, Fundamental Theorem of Curves, Co-ordinate Patch, Surfaces, Parametric Curves, First Fundamental Form.<br>UNIT 3<br>Normal Curvature, Geodesic Curvature, Gauss Formula, Christoffel Symbols, Second Fundamental Form.<br>UNIT 4<br>Orientability, Geodesics, Geodesics on Surface of Revolution, Geodesics on Sphere.<br>UNIT 5<br>Weingarten Equations, Principal Directions, Principal Curvatures, Gaussian Curvature, Mean Curvature, Line of Curvature, Asymptotic Curve, Minimal Surface.<br><br>SUGGESTED READING:<br>DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES: M. P. do Carmo<br>ELEMENTS OF DIFFERENTIAL GEOMETRY: Millman and Parker<br>ELEMENTARY DIFFERENTIAL GEOMETRY: Andrew Pressley | |
| MAM 603 METHODS OF APPLIED MATHEMATI | UNIT I<br>Laplace transform and its properties, Convolution Theorem. Laplace transform of derivatives and periodic functions. Error and complementary functions and their Laplace transforms. | As suggested in the BOS meeting, Units V is deleted, Unit I split into Units I and II, |

| | | |
|---|---|---|
| CS | UNIT II<br>Inverse Laplace transforms, Application of Laplace transforms to the solution of ordinary and partial differential equations.<br>UNIT III<br>Fourier series: an expansion theorem, Fourier sine series, cosine series, the one dimensional heat equation, surface temperature varying with time, heat conduction in a sphere, a simple wave equation, Laplace's equation in 2 dimensions<br>UNIT IV<br>Exponential Fourier transform, Fourier Sine and Cosine transforms and their applications in solving partial differential equations.<br>UNIT V<br>Integral Equations: Conversion of Ordinary Differential Equations into Integral equations, Classification of Linear Integral Equations and Introductory methods of their solutions, Eigen functions of integral equations.<br><br>SUGGESTED READINGS:<br>RV Chruchill: OPERATIONAL MATHEMATICS<br>IN Sneddon: THE USE OF INTEGRAL TRANSFORMS<br>CJ Tranter: INTEGRAL TRANSFORMS<br>DV Widder: AN INTRODUCTION TO TRANSFORM THEORY<br>RM Rao & AS Bopardikar: WAVELET TRANSFORMS | Unit II renamed as Unit IV, Unit III shifted to MAM 701, Unit IV renamed as Unit V and Unit V of MAM 503 shifted to Unit III |
| MAM 605 PROGRAMMING LAB | MATLAB and Exercises based on MAM604-Numerical Analysis | As suggested in BOS meeting, Lab course restructured and designed in accordance with the changes in the courses. |
| MAM 606 COMPLEX ANALYSIS | Schwarz's Lemma included in Unit 3<br><br>(Earlier MAM 502 in 2014-15 syllabus) | As suggested in BOS meeting. |
| MAM701 (MEASURE THEORY & LEBESGUE INTEGRATION) | UNIT 1<br>Algebra and σ algebra of sets, set measures, countably additive set measure, outer measure of set, measurable sets, Lebesgue measure, Lebesgue measurable functions- sum, product and compositions, sequential pointwise limits.<br>UNIT 2<br>Lebesgue integration- Lebesgue integral of a bounded measurable function over a set of finite measure, Lebesgue integral of a non negative measurable function.<br>UNIT 3<br>General Lebesgue integral, Convergence theorems- Bounded Convergence, Fatou's lemma, monotone convergence and dominated convergence theorems.<br>UNIT 4<br>$L^p$ spaces - Holder's and Minkowski's inequalities, $L^p$ space as a metric space, essentially bounded spaces, Convergence in $L^p$ space, Completeness of $L^p$ space.<br>UNIT 5<br>Inverse function theorem and Implicit function theorem – Proofs and applications of the theorems. | As per the discussions in BOS meeting, measure theory and lebesgue integration which is important from NET point of view forms this new course. Additionally it contains two important theorems, namely- Inverse function theorem and Implicit function theorem. |

| | | |
|---|---|---|
| MAM703 THEORY OF DIFFERENTIAL EQUATIONS | UNIT 1<br>Elementary Concepts about Differential Equations, Lipschitz condition, Gronwall inequality, Existence and Uniqueness of solutions for scalar and systems of equations.<br>UNIT 2<br>Linear Differential Equations with Variable Coefficents, Linear Dependence and Independence of Solutions, Concept of Wronskian, Oscillatory and Non-oscillatory Behaviour of Solutions of Second Order Linear Differential Equations, Non-Homogenous Equations, Strum-Liouville Boundary Value Problem, Green's Function.<br>UNIT 3<br>Fundamental matrix, Non-homogenous Linear Equations, Linear Systems with constant coefficients, Linear Systems with Periodic Coefficients.<br>UNIT 4<br>Stability of Linear Systems, Behaviour of solutions of Linear Differential Equations.<br>Unit 5<br>Stability of Nonlinear Differential Equations, Applications of Poincare Bendixon Theorem, Introductory Methods of Solution of Linear Integral Equations. | Topics Sturm-Liouville's Problem, Oscillatory and Non-oscillatory Behaviour of Solutions of Second Order Linear Differential Equations and Green's Function included in Unit II; Applications of Poincare Bendixon Theorem included in Unit V. |
| MAM 704 MATHEMATICAL MODELLING | Earlier MAM805 in 2014-15 syllabus | |
| MAM705 ALGEBRA IV (Field Theory) | UNIT I<br>Polynomial Rings, Roots of a Polynomial, Division Algorithm, Irreducibility of a Polynomial, Mod p Irreducibility Test, Eisenstein Criterion, Irreducibility of *p*th Cyclotomic Polynomial<br>UNIT II<br>Quadratic Integer Rings, Euclidean Domain, Principle Ideal Domain, Unique Factorization Domain.<br>UNIT III<br>Extension of a Field, Finite Extension, Algebraic Extension, Simple Extension, Algebraic Number, Transcendental Number, Construction with Straight Edge and Compass.<br>UNIT IV<br>Roots of a Polynomial in an Extension Field, Separability of Polynomials, Splitting Field, Separable Extension, Cyclotomic Extension.<br>UNIT V<br>Finite Fields, Structure of Finite Fields, Extension of a Finite Field, Classification of Finite Fields, Finite Fields as Simple Extensions and their Degree, Subfields of a Finite Field.<br><br>SUGGESTED READING:<br>ALGEBRA: Michael Artin<br>ABSTRACT ALGEBRA: D. S. Dummit and R. M. Foote<br>CONTEMPORARY ABSTRACT ALGEBRA: J. A. Gallian<br>TOPICS IN ALGEBRA: I. N. Herstein | As observed in the BOS meeting, Course Contents were heavy. So the contents have been restructured, and some of the contents shifted to MAM 911. |
| MAM706 SOFTWARE LAB | 1. (Common for all students) Concepts of Object Oriented Programming with Java: Classes, Objects, Methods, Inheritance, Interfaces, Exceptions, Packages and Java Package Library.<br>2. For Students Opting for MAM704-Mathematical Modelling only MATLAB exercises based on models developed in | As suggested in BOS meeting, Lab course restructured and designed in accordance with the changes in the |

| | | |
|---|---|---|
| | MAM704.<br>3. For students Opting for MAM904-Fuzzy Sets and Systems only.<br>MATLAB exercises based on models developed in MAM904.<br>4. For students of M.Sc. Mathematics with Specialization in Computer Applications only Java Applets and Java Swing. | courses. |
| MAM801 ADVANCED OPTIMIZATION TECHNIQUES | UNIT 1<br>Queueing Theory: Introduction, Definitions and Notations, Classification of Queueing Models, Distribution of Arrivals (The Poisson Process): Pure Birth Process, Distribution of Inter Arrival Times, Distribution of Departures (Pure Death Process), Distribution of Service Time, Solution of Queueing Models, Poisson Queues-(M/M/1):(∞/FIFO), (M/M/1):(N/FIFO), (M/M/C):(∞/FIFO), (M/M/C):(N/FIFO).<br>UNIT 2<br>Non-Linear Programming Problem (NLPP): Introduction, Maxima and minima of functions of several variables and their solutions, Quadratic forms, Concave and convex functions, Unconstrained and constrained optimization.<br>UNIT 3<br>Constrained NLPP: Lagrange's method, Kuhn-Tucker conditions, Graphical Method, Concept of Quadratic programming, Frank-Wolfe method. Unconstrained NLPP: Fibonacci and Golden section search, Steepest Descent Method, Conjugate metric method.<br>UNIT 4<br>Dynamic Programming: Multistage decision processes, Concept of sub-optimality, Principle of optimality, Calculus method of solution, Tabular method of solution, LPP as a case of dynamic programming.<br>UNIT 5<br>Integer programming: Gomory method for pure and mixed LPP, All pure and mixed integer programming, Algorithm and solution of numerical problems, Branch and bound method. | As suggested in BOS meeting, course content of MAM801 and MAM402 is restructured in accordance with the syllabus of new programme Post Graduate Diploma in Big Data, Logistics and Operations Research (PGDBDLOR) proposed by Department of Mathematics. |
| MAM802 ALGEBR V (Canonical Forms) | UNIT I<br>Geometric and Algebraic Multiplicity, Direct Sum of Subspaces, Direct Sum of Eigenspaces, Diagonalizability of Matrices and Linear Operators.<br>UNIT II<br>Minimal Polynomial, Invariant Subspaces, Conductor, Minimal Polynomial & Diagonalizability, Minimal Polynomial & Triangulability, Cyclic Subspace, Cayley-Hamilton Theorem, Companion Matrix.<br>UNIT III<br>Generalized Eigenspace, Cycle of Generalized Eigenvectors, Direct Sum of Generalized Eigenspaces, Jordan Form, Rational Form.<br>UNIT IV<br>Rigid Motion, Translation, Rotation, Reflection, Orthogonal Operators on $R^2$ and $R^3$.<br>UNIT V<br>Bilinear Form, Matrix Representation, Diagonalizability of a Bilinear Form, Quadratic Forms and their Reduction.<br><br>SUGGESTED READING:<br>ALGEBRA: Michael Artin<br>LINEAR ALGEBRA: S. H. Friedberg, A. J. Insel and L. E. Spence | As observed in the BOS meeting, Course Contents were heavy. So the contents have been restructured, New Topics added and some of the contents shifted to MAM 705. |

| | | |
|---|---|---|
| | CONTEMPORARY ABSTRACT ALGEBRA: J. A. Gallian<br>TOPICS IN ALGEBRA: I. N. Herstein<br>LINEAR ALGEBRA: K. Hoffman and R. Kunze | |
| MAM803<br>FLUID<br>DYNAMICS | UNIT 1<br>The Equation of Continuity in Cartesian, Polar and Spherical coordinates, Boundary Surface, Eulerian and Lagrangian forms of equation of continuity. Symmetrical form of equation of continuity, Equation of Motion, Pressure equation, Lagrangian equation of motion, Helmholtz vorticity equation, Cauchy's integral.<br>UNIT 2<br>Viscosity, The Navier-Stokes equations of motion, Euler's Equation, Bernoulli's Equation, steady motion between parallel planes, steady flow through a cylindrical pipe, steady flow between concentric rotating cylinders.<br>UNIT 3<br>Meaning of two-dimensional flow, velocity potential and Stream function, Complex potential for irrotational, incompressible flow, complex potentials for line source, sinks and doublets, two dimensional image systems, circle theorem, the theorem of Blasius.<br>UNIT 4<br>Vortex filaments, complex potential due to a vortex of strength +k, motion due to m vortices, two vortex filaments, image of vortex w.r.t. a plane, image of vortex w.r.t. a cylinder, complex potential due to vortex doublet, vortex sheet, infinite single row of vortices of equal strength, two infinite rows of vortices, Karman's vortex sheet.<br>UNIT 5<br>Non dimensional numbers, Prandtl's boundary layer theory, Karman's integral equation. | As observed in the BOS meeting, Course Contents were heavy. So Unit V has been deleted and the remaining contents have been restructured<br>in five units. |
| MAM804<br>FUNCTIONA<br>L ANALYSIS | UNIT 1<br>Normed Linear Space, Banach Space, Finite Dimensional Normed Linear Space, Compactness and Finite Dimension, Continuity of a Linear Map, Norm of a Continuous Linear Map, Isometric Isomorphism.<br>UNIT 2<br>Dual Space, Natural Embedding of a Normed Linear Space in its second Dual Space, Weak Topology, Principle Conjugate of an Operator.<br>UNIT 3<br>Hahn-Banach theorem, Open Mapping Theorem, Closed Graph Theorem, Uniform Boundedness principle.<br>UNIT 4<br>Hilbert space, Schwarz's inequality, orthogonal complement of a set, orthonormal set, complete orthonormal set, Bessel's inequality, Fourier's expansion, Parseval's equation, Gram Schmidt orthogonalisation process, Dual and second Dual of Hilbert space.<br>UNIT 5<br>Adjoint of an Operator, Self Adjoint Operators, Normal Operators, Unitary Operators, Projection on a Linear Space, Banach Space and Hilbert Space, Spectral Theorem. | The course seemed to be too heavy for a 4 credit course as per the discussions in BOS. Therefore, the last unit on Banach Algebra is removed. The remaining content has been restructured. |
| MAM805<br>STOCHASTI<br>C PROC.<br>AND STAT. | UNIT 1: STOCHASTIC PROCESSES<br>Stationary processes, Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities, Markov processes in continuous time, | As suggested by the members of BOS meeting, course contents were heavy, |

| | | |
|---|---|---|
| INFERENCE | Poisson process, birth and death process.<br>UNIT 2: THEORY OF ESTIMATION<br>Point Estimation, Criterion of unbiasedness, Consistency, sufficiency, Cramer-Rao inequality, Uniformly minimum variance unbiased estimators, Methods of estimation: maximum likelihood moments, minimum chi-square, least square, confidence interval estimation.<br>UNIT 3: TESTING OF HYPOTHESIS<br>Basic concepts, types of errors, critical region, power function, most powerful and uniformly most powerful tests, likelihood ratio test, Wald's sequential probability ratio test.<br>UNIT 4: RELIABILITY THEORY<br>Definition, Failure, Data Analysis, Hazard, Models, System Reliability Series, Parallel and Mixed Configurations.<br>UNIT 5: DESIGN OF EXPERIMENTS<br>Basic principles of experimental design, randomization structure and analysis of completely randomized, randomized block and Latin-square designs. Factorial experiments. Analysis of $2^n$ factorial experiments in randomized blocks. | so some of the relevant topics have been shifted to MAM 606 to maintain the continuity and to teach the subject in depth. |
| MAM806 SOFTWARE LAB | 1. For all students: MATLAB exercises on MAM801-Advanced Optimization Techniques.<br>2. For students of M.Sc. Mathematics with Specialization in Computer Applications only: Exercises based on MAM807-Internet Technologies. | As suggested in BOS meeting, Lab course restructured and designed in accordance with the changes in the courses. |
| MAM812 GRAPH THEORY | Earlier MAM602 in 2014-15 syllabus. | |
| MAM905 ANALYTICAL MECHANICS | UNIT 1<br>Calculus of Variations: Euler-Lagrange equation, Functionals of the form $\int F(x, y_1, y_2, \ldots, y_n, y_1', \ldots, y_n')\, dx$, Functionals dependent on higher order derivatives, Functionals dependent on the functions of several independent variables, Variational methods for boundary value problems in ordinary differential equations.<br>UNIT 2<br>Generalised co-ordinates. Generalised velocities. Vertual work and genralised forces. Lagrange's equations for a holonomic system. Case of conservative forces. Generalised components of momentum and impulse. Lagrange's equation for impulsive forces. Kinetic energy as aquadratic function of velocities. Equilibrium configuration for conservative holonomic dynamical system. Theory of small oscillations of conservative holonomic dynamical system.<br>UNIT 3<br>Variational methods. The Brachistochrone problem. Hamilton's principle. The principle of least action. Distinction between Hamilton's principal and principal of least action.<br>UNIT 4<br>Hamilton's equations--the Hamiltonian and the canonical equatios of motion. The passage from the Hamiltonian to the Lagrangian. The Hamilton--Jacobi equation and its complete integral. Phase space. Poisson brackets. Liouville's theorem.<br>UNIT 5<br>Motion about a fixed point-Euler's dynamical equations. Motion under no forces about-rotating axes. | Units I and V restructured as suggested in BOS meeting. |

| | | |
|---|---|---|
| MAM911<br>GALOIS THEORY | UNIT I<br>Commutator Subgroup, Normal Series, Solvable Group, Solvability of Permutation Groups.<br>UNIT II<br>Group of Automorphisms of a Field, Galois Group, Frobenius Automorphism, Galois Group of Splitting Fields of Some Polynomials.<br>UNIT III<br>Galois Extension, Intermediate Field, Fundamental Theorem of Galois Theory.<br>UNIT IV<br>Solvability by Radicals, Pure Extension, Radical Extension, Solvability of Galois Group.<br>UNIT V<br>Solution of a Cubic & Quartic, Non- Solvability of a Quintic, Discriminant, Casus Irreducibilis.<br><br>SUGGESTED READING:<br>ALGEBRA: Michael Artin<br>ABSTRACT ALGEBRA: D. S. Dummit and R. M. Foote<br>CONTEMPORARY ABSTRACT ALGEBRA: J. A. Gallian<br>GALOIS THEORY: Joseph Rotman | A new course introduced to cover important topics from NET syllabus in due detail. |
| MAM955<br>SPECIAL TOPICS IN MATHEMATICS | UNIT 1<br>Spectral radius, spread, singular values. Properties of Normal Matrices, Schur's Theorem, Diagonalizability of Normal and Self-adjoint Operators, The singular value decomposition and the pseudoinverse.<br>UNIT 2: SPECIAL FUNCTIONS<br>Analytical behaviour of Gamma and Beta functions, Pochhamar symbols. 2F1[a,b;c,z] function, convergence, differential equations of 2F1, Contiguous Relations, Transformations, integral representations.<br>UNIT III<br>Construction of Real Numbers through Dedekind Cuts, Other Constructions, Continuum Hypotheses, Existence of *n*th roots of Positive Reals.<br>UNIT 4: PARTIAL DIFFERENTIAL EQUATIONS OF SECOND ORDER<br>Introduction, Equation Reducible to Linear Form, Equation Integrable by Lagrange's method, solution of Equations under given Geometrical conditions, Monge's Method to solve $Rr+Ss+Tt+U(rt-s^2)=V$, Canonical Forms, Special Forms of II order Equation.<br>UNIT V<br>Matrix Groups: Classical linear Groups, Dimension as a Vector Space, Topological Properties. | Some topic included in Unit I. Units III & V changed to include important topics which were not covered earlier. |