Academic Audit Report (M.Sc. Curriculum and B.Tech Courses)-2023

The Department of Mathematics conducted the academic audit of M.Sc. Curriculum and B.Tech. Core courses. Following is the list of experts for the academic audit:

1. Prof. A K Nandakumaran (IISc Bangalore)
2. Prof. Debasis Kundu (IIT Kanpur)
3. Prof. Manjul Gupta (IIT Kanpur)
4. Prof. A K Pani (IIT Bombay)
5. Prof. B S Panda (IIT Delhi)
6. Prof. Y V S S Sanyasiraju (IIT Madras)
7. Prof. Jaydeb Sarkar (ISI Bangalore)

Three to four courses (CIF, Assignments, Tutorials, Quizzes, Midterm, End term) along with the M.Sc. programme were assigned to each expert for academic audit. Each expert provided their suggestions/comments in detail. The department conducted four meetings (each two hours long) to discuss the suggestions/comments provided by the experts for each course. The department made a comprehensive academic audit report which contains expert recommendations and the action taken by the department. The complete academic audit report with action taken by the department is attached.

The department thanks each expert for providing valuable suggestions/comments.

09/08/23

Dr. Manish Garg
(HoD Mathematics)

Prof. MK Kadalbajoo

Dr. Ajit Patel

Dr. Vikas Gupta

09/08/2023

Dr. Pratibha Garg

Dr. Sunil Kumar Gauttam

H.C. Trivedi

Dr. Trivedi Harsh Chandrakant

Dr. Sudipto Chowdhury

10/9/23

Dr. Ratan k. Giri

Dr. Ashish Mishra

Academic Audit Report -2023

(Department of Mathematics)

Institute Core Courses (B.Tech.)

Course Code	Course Description	Name of the Auditor
MTH102	Mathematics-I	Prof. Jaydeb Sarkar
MTH108	Mathematics-II	Professor Y V S S Sanyasiraju IIT-Madras
MTH201	Mathematics-III	A.K. Nandakumaran IISC,Bangalore
MT222	Probability & Statistics	Debasis Kundu IIT Kanpur

Name of the Course: Mathematics I	
Name and Affiliation of Auditor: Professor Jaydeb Sarkar Name of Institution: ISI Bangalore	Action Taken

Recommendation from the auditor: **Textbooks:** The text book is very good. Bartle and Sherbert's book is a classic and will be beneficial for students. However, I am a little uneasy about the books by Kumaresan et al. **Ref. Books (Suggested)** 1. An illustrative guide to multivariable and vector calculus. By Stanley J. Miklavcic. Springer. [Excellent book for several variables: to the point and quicker in introducing newer concepts]. 2. Calculus Volume 1 & 2. 2nd Edition by Tom Apostol [These are remarkable books, can be used for many other courses, and will stay with the students forever. This will take care of several variables too]. 3. Introduction to real analysis by William F. Trench [Most probably it is now a free edition] **Overall Comment:** The course is well-balanced, of high quality, and consistent with comparable courses at other IITs. I have some comments regarding the reference book that may be accepted or rejected based on other criteria. The course is flawless, and I strongly suggest acceptance.	• Both books on **single variable and multi variables** by R. Ghorpade and Balmohan Limaye are added as textbooks from the reference Books. • Book **Calculus and Analytic Geometry** by G. B. Thomas and R. L. Finny will also be a textbook. • Book **A Basic Course in Real Analysis** by Ajit Kumar and S. Kumaresan is kept as a reference book. • The book **Introduction to Real Analysis** by Bartle and Sherbert is already in the reference book. • Book **An illustrative guide to Multivariable and vector calculus** By Stanley J. Miklavcic, Springer, is added as a reference book. • Book **Elementary Analysis: The Theory of Calculus** by Kenneth A. Ross Kenneth a Ross is added in reference. • Department feels that these reference Books and Textbooks are suitable for our students.

Name of the Course: Mathematics II	
Name and Affiliation of Auditor: Professor Y V S S Sanyasiraju Name of Institution: IIT Madras	Action Taken
Recommendation from the auditor: Course content is appropriately designed and good for the B.Tech. students.	• No action is required. However, Department feels that the following books should be removed/added • Book **Linear Algebra** by Kenneth Hoffman & R. Kunze is removed from textbooks. • Book **Introductory Linear Algebra: An Applied First Course: By B. Kolman and D. R. Hill** is added in the textbook.

Name of the Course: Mathematics III	
Name of the Auditor: A.K. Nandakumaran Indian Institute of Science, Bangalore	Action Taken:
Recommendation from the auditor: Course Outcomes: Problems given in both assignments and exams are quite routine like any other engineering colleges. There are no problems which require thinking. This comment is not only for the present paper, but for other courses as well. Need to add questions which require critical thinking not necessarily tough. Book Suggestion: J. B. Conway, Functions of one complex Variables I, Narosa Publishing House	• Book J.B. Conway is added as a reference book. • Department feels that assignments are appropriate for our students however department will work further to enrich the assignments as suggested.

Name of the Course: Probability and Statistics	
Name of the Auditor and affiliation: Debasis Kundu, IIT Kanpur	Action Taken
Recommendation from the auditor: Book Suggestion: Hogg, R. V. and Craig, A., "Introduction to Mathematical Statistics", Pearson Education, 6th Ed. It contains more Statistical concepts along with probability material. Evaluation: Later portion of the course was not included in the evaluation process. I believe that the instructor could not cover the whole course materials, and I cannot blame the instructor. Overall Comments: My overall comment is that it is a too ambitious course. It is not possible to teach so many topics in one course, and it is not possible to do justice if you would like to teach all the topics. It is very clear from the quiz, mid-sem and end-sem question papers that most of the statistics portions have not been touched. So in my opinion, if it is possible, divide it into two courses, one purely on basic probability and the other on basic statistics. Alternatively, divide 40 Lectures into 20+20, i.e. 20 lectures for Basic probability and 20 lectures for Basic Statistics. It is definitely not possible to cover so many probability topics in 20 lectures. But definitely it is important to cover some basic topics in Statistics also.	• Department has revised the lecture plan using the suggested book's 8th edition.

First Semester

Course Code	Course Description	Name of the Auditor
MTH6011	Analysis-I	Prof. Manjul Gupta,IIT-K
MTH6041	Linear Algebra	Prof.B.S. Panda,IIT-D
MTH6021	Optimization	Prof.B.S. Panda,IIT-D
MTH6012	Algebra	Prof.B.S. Panda,IIT-D

Name of the Course: **Analysis-I (Odd Semester)**	
Name of Auditor: Professor (Retd.) Manjul Gupta Name of Institution: IIT Kanpur	Action Taken
Recommendation from the auditor: Book Recommendation: Real Analysis by N.L. Carothers CambridgeUniversity Press	• The suggested book is added in the reference section of the CIF.

Name of the Course: **Linear Algebra**	
Name of the Auditor and affiliation:Prof. B.S. Panda IIT Delhi	Action Taken
Recommendation from the auditor: Evaluation Component: Needs improvement (Quizzes must test concepts rather than solving problem in tests) Lab Experiment- Tools/Platforms: Use of Python and MATLAB Overall Comments: Include some topics such as PCA which has applications in Data Science. Have assignments based on the algorithms taught in the course such as solving linear systems, finding rank, finding inverse, finding eigen values and eigen vectors etc.	Recommended programming components are already included in the Numerical Analysis and Scientific Computing course. PCA is not included as background of some of the admitted students is not usually good and course contents are too much to complete in a semester.

Name of the Course: **Optimization**	
Name of the Auditor and affiliation: Prof. B.S. Panda IIT Delhi	Action Taken
Recommendation from the auditor: **Sequence of the Course** Remove the queueing Theory part (Unit-2) and Expand the Unit-1 Part. Treatment of Networks optimization problems using Mathematical programming is missing.(Complementary slackness conditions, revised simplex method, primal dual method etc need to added) **Textbook:**LINEAR PROGRAMMING and Network flows by MOKHTAR S. BAZARAA, John J. Jarvis and HANIF D. SHERALI, to expand Unit-1. **Evaluation:** Quizzes are like test questions. It should test the fundamental concepts learned, such as (i)modeling a problem as LPP or ILP, optimality criteria etc. **Lab Experiment:**Need to have a software such as **Cplex** to experiment with large scale problems.	• The Department has the view to keep the Queuing Theory part in the CIF as discussed in the BoS. • The quizzes are well balanced as per the standard of the students. • Students are already using C/C++/MATLAB to solve programming problems. Further Department will also explore introducing the Cplex.

Name of the Course: **Algebra**	
Name of the Auditor and affiliation:Prof. B.S. Panda IIT Delhi	Action Taken
Recommendation from the auditor: **Evaluation:** Quizzes are like test questions. It should test the fundamental concepts learned. **Lab Experiment:** Either Python or Matlab should be used for programming assignments (for finite permutation group and finite fields) **Overall Comments:** The Group Theory Module is heavy taking into the fact that Group theory is taught in BSC and included in the JAM Syllabus. I suggest to include some applications of finite fields in coding theory.	• Department will enrich quiz problems by setting MCQ/fill in the blanks type of questions with emphasis on fundamentals of the topic. • The lab experiment is not feasible as students are having the first course in programming (5 credits), and programming evaluation components are there in the optimization course. • Applications of finite fields in coding theory are not included as the background of admitted students is not usually good in group theory, and course contents are too much to complete in a semester.

Second Semester

Course Code	Course Description	Name of the Auditor
MTH6031	Probability and Statistics	Prof.Debasis Kundu,IIT-K
MTH6022	Analysis-II	Prof. Manjul Gupta,IIT-K

MTH6032	Complex Analysis	Prof. Jaydeb Sarkar
MTHXXXX	Numerical Analysis	Professor Y V S S Sanyasiraju IIT-Madras
MTH6042	Ordinary Differential Equations	A.K. Nandakumaran IISC, Bangalore

Name of the Course: **Probability and Statistics**	
Name of the Auditor and affiliation: Debasis Kundu, IIT Kanpur	Action Taken

Recommendation from the auditor: Book Suggestion: Hogg, R. V. and Craig, A., "Introduction to Mathematical Statistics", Pearson Education, 6th Ed. It contains more Statistical concepts along with probability material. Evaluation: Later portion of the course was not included in the evaluation process. I believe that the instructor could not cover the whole course materials, and I cannot blame the instructor. Overall Comments: My overall comment is that it is a too ambitious course. It is not possible to teach so many topics in one course, and it is not possible to do justice if you would like to teach all the topics. It is very clear from the quiz, mid-sem and end-sem question papers that most of the statistics portions have not been touched. So in my opinion, if it is possible, divide it into two courses, one purely on basic probability and the other on basic statistics. Alternatively, divide 40 Lectures into 20+20, i.e. 20 lectures for Basic probability and 20 lectures for Basic Statistics. It is definitely not possible to cover so many probability topics in 20 lectures. But definitely it is important to cover some basic topics in Statistics also.	• Department has revised the lecture plan using the suggested book's 8th edition.

Name of the Course: **Analysis-II** (Even Semester)	
Name of Auditor: Professor (Retd.) Manjul Gupta Name of Institution: IIT Kanpur	Action Taken
Recommendation from the auditor: Book Recommendation: G.De Barra, Measure Theory and Integration, Wiley Eastern Ltd.1981 may be followed as a textbook.	• It is already a reference book. It is up to the faculty to use it as a text book.

Name of the Course: **Complex Analysis**	
Name and Affiliation of Auditor: Professor Jaydeb Sarkar Name of Institution: ISI Bangalore	Action Taken

Recommendation from the Auditor: Book Recommendation: Complex Function Theory. By Donald Sarason. Hindustan book agency. **General Comment for Course Context and Overview:** I would replace the first and second sentences in the ``Course context and overview'' with the following paragraph. As it is mildly misleading:  `` The objective is to investigate functions defined on complex plane C. By separating these functions into their real and imaginary parts, they can be viewed as functions from the real plane to itself. However, taking into account the field structure of C, as opposed to the vector space structure of the two-dimensional real plane, one finds a remarkable analytic structure for such functions. Complex differentiable functions, for instance, have many extraordinary properties that their counterparts with one or two real variables lack.''	• The suggested book has been included in the reference section of the CIF. Learning objective has been updated as suggested.

Name of the Course: **Numerical Analysis**	
Name and Affiliation of Auditor: Professor Y V S S Sanyasiraju, IIT Madras	Action Taken
Recommendation from the auditor: Book Suggestion: Sufficient text and reference books are already indicated. However, Numerical Analysis: David Kincaid and Ward Cheney, Mathematics of Scientific Computing, (2002), may be more appropriate for the M.Sc. students. Overall Course content is appropriately designed and good for M.Sc. and also for the final year B. Tech. students.	• This course is replaced by a new course, Numerical Analysis and Scientific Computiong based on the recommendation of BoS. • The suggested book is added as reference book in the CIF.

Name of the Course: **Ordinary Differential Equations**	
Name of the Auditor and affiliation: A.K. Nandakumaran Name of Institution: Indian Institute of Science, Bangalore	Action Taken:

Recommendation from the auditor: Course Outcome/Sequence of the Course: The course can begin with a large number of examples of very simple ODEs to demonstrate or motivate why we study existence, uniqueness, stability etc. It is important to give examples with no existence, no uniqueness, no global solutions etc. Hence the first part of the first unit can be examples. Course should begin with few motivating examples. Book Suggestion: Textbooks are standards but one can add following reference books. A.K.Nandakumaran, P.S. Datti and Raju K. George; Ordinary Differential Equations: Theory and Applications, Cambridge-IISc Series, Cambridge university Press (2017). There is also an NPTEL Course given by the same authors in 2004. Standard of Question Paper Easy and standard as the questions are straight forward. A couple of thinking (not necessarily tough) questions included. I prefer 20 % of critical thinking questions.	• CIF has been updated as suggested • The examples as suggested are done in the class. Nandkumaran's book is added as a reference book. The suggestion regarding the question paper will be taken care of.

Third Semester

Course Code	Course Description	Name of the Auditor
MTH7011	Topology	Prof. Manjul Gupta,IIT-K
MTH7021	Functional Analysis	Prof. Manjul Gupta,IIT-K
MTH7031	Partial Differential Equations	Prof. A.K.Nandakumaran IISC,Bangalore

Name of the Course: **Topology** (Odd Semester)	
Name of Auditor: Professor (Retd.) Manjul Gupta Name of Institution: IIT Kanpur	Action Taken
Recommendation from the auditor: Book Recommendation: 1. Introduction to general topology by K.D. Joshi New age International Publishers 2. Point Set topology by Steven A. Gaal Dover Publication	• Both suggested books are added in the CIF.

Name of the Course: **Functional Analysis** (Odd Semester)	
Name of Auditor: Professor (Retd.) Manjul Gupta Name of Institution: IIT Kanpur	Action Taken
Recommendation from the auditor: About Course Content: Unit-VI may be removed as course contents are too much to complete in a semester. Book Recommendation: Introductory Functional Analysis with Applications by Erwin Kreyszig Wiley	• Unit-VI is removed as course contents are too much to complete in a semester. • Kreyszig's book is added as a reference book in the CIF.

Name of the Course: **Partial Differential Equations**	
Name and Affiliation of Auditor: Professor A.K. Nandakumaran Name of Institution : Indian Institute of Science, Bangalore	Action Taken:

Recommendation from the auditor: About Course Outcomes: It is important to introduce the method of characteristics starting with linear equations then quasi linear equations and then fully linear equations with geometric picture which will motivate charpit's methods. Give some examples from linear, quasilinear (conservation laws) and fully non-linear. Mere introduction of Cauchy-Kowalevski will not help much. Need to introduce series solutions. About Course Contents Sequence breadth and depth: The sequence is organized decently except for comment 1. The course should begin with a few motivating examples 2. Methods of characteristics should be explained in detail as this is an important concept in PDE. 3. A good analysis course is needed prior to the PDE course for better understanding. Suggested Books/Reference: Textbooks are standard books but one can add many reference books. Suggested that Sneddon is a very old reference and does not motivate much about PDE. Reference book details: A.K.Nandakumaran and P.S. Datti: Partial Differential Equations: Classical Theory with a Modern Touch, Cambridge-IISc Series, Cambridge university Press (2020).	• Course outcomes have been updated. The suggested book has been added in the CIF. • The question paper is standard and as per the level of students. There are also few questions which required critical thinking.

About question paper Easy and standard as the questions are straight forward. A couple of critical thinking questions should be included.	

Fourth Semester

Course Code	Course Description	Name of the Auditor
MTH7041	Mathematical Methods	Prof. Amiya Kumar Pani BITS Pilani,Goa Campus

Name of the Course: **Mathematical Methods**	
Name of the Auditor: Amiya Kumar Pani Name of Institution: BITS-Pilani, KK Birla Goa Campus, Goa	Actions Taken
Recommendation from the auditor: About Evaluation component: Questions are more or less of routine type, therefore it is requested to ask a couple of questions which will distinguish between the average and good students with proper understanding. Overall View: Last part on tempered distribution and generalized Fourier transform will be somewhat difficult at this stage, therefore, more emphasis can be given on problem solving on Fourier transforms.	• The level of question paper has been maintained to distinguish between good and average students, which also gets reflected in the grading. • It was suggested in the last BoS meeting to include the topics on Schwartz's spaces, tempered distribution and generalized Fourier transform so that the topics become more interesting. Therefore keeping them in the syllabus. • However keeping the recommendations in mind more emphasis will be given on problem solving on Fourier transforms.

Program Elective & Open Electives

Course Code	Course Description	Name of the Auditor
MTH7071	Number Theory	Prof. B.S. Panda IIT Delhi
MTH7022	Finite Element Methods	Amiya Kumar Pani BITS Goa Campus
MTH7051	Numerical Methods PDE	Amiya Kumar Pani BITS Goa Campus
MTH4031	Introduction to Fractional Calculus	Amiya Kumar Pani BITS Goa Campus

Name of the Course: **Number Theory**	
Name of the Auditor and affiliation:Prof. B.S. Panda IIT Delhi	Action Taken
Recommendation from the auditor: **Evaluation:** Quizzes are like test questions. It should test the fundamental concepts learned. **Lab Experiment:** I think labs regarding Basic Number Theoretic algorithms should be included. **Overall Comments:** This course looks fine except that coverage of the Cryptography portion is less.	• The quizzes are designed to see whether students can apply the theorem /concepts done in the classes or not. • The evaluation component on programming has been added to the CIF. • This is an introductory course on number theory. There is another elective course on cryptography.

Name of the Course: **Finite Element Methods**	
Name of the Auditor: Amiya Kumar Pani Name of Institution: BITS-Pilani, KK Birla Goa Campus, Goa	Action Taken
Recommendation from the auditor: Suggested to make lab assignments a part of the evaluation process.	• This course is renamed as Finite Element Analysis. • The course contains the Lab component: Implementation of algorithms, computational experiments using MATLAB, FreeFEM++. • The course begins with Distribution theory, and Sobolev spaces before starting of FEM, which is a somewhat

	advanced level for the M.Sc. students. Because of heavy courses, there is no time to have a lab assignment for the evaluation process, although a demonstration of a few codes is being done during the course.

Name of the Course: **Numerical Methods PDE**	
Name of the Auditor: Amiya Kumar Pani Name of Institution: BITS-Pilani, KK Birla Goa Campus, Goa	Action Taken
Recommendation from the auditor: For Sequencing of the Course: FDM for elliptic can be done earlier before starting parabolic and Wave, but the sequencing of elliptic at the last is ok. This sequencing has some advantage like start with 1D problem, which are relatively easy and revealing. No change in sequencing. Book Suggestion Stig Larsson , Vidar Thomee, Partial Differential Equations with Numerical Methods, Texts in Applied Mathematics, 45,1st ed. 2003. 2nd printing 2008 Edition, Springer Verlag, Berlin.\ Evaluation Process There should be lab assignments as a part of evaluation process. If possible include lab component.	• Suggested book is added as a reference book in the CIF • Few programming assignments are added.

Name of the Course: **Introduction to Fractional Calculus**	
Name of the Auditor and affiliation: Amiya Kumar Pani, BITS-Pilani,KK Birla Goa Campus	Action Taken
Recommendation from the auditor: Book Suggestion K. Diethelm, The analysis of fractional differential equations, Lecture notes in Mathematics, Springer-Verlag, Berlin, 2010. A.A. Kilbas, H.M. Srivastav and J.J. Trujillo, Theory and Applications of Fractional differential Equations, North-Holland Mathematics Studies Vol. 204, Elsevier, Amsterdam, 2006. Overall In this course, more emphasis may be given to fractional Differential Equations, say by cutting down materials like Sections 2.8, 3.4. More hours may be given for fractional Differential Equations and their numerics. 1.8 may not be relevant here as we discuss the $t>0$ case. 3.4 on power series, may be dropped.	• Suggested books are added as reference books in the CIF • This is an introductory course, as students don't have any prior idea of the topic. So considering this fact and the level of the M.Sc. students the course content remains as it is except the omission of some topics from Section 3.4. • (There is a typo error in the recommendation from the auditor. Section 2.8 is written as Section 1.8 in the second last line.)

Program Audit Reports

Name of the Course: Programme Audit Report	
Name of the Auditor and affiliation: Debasis Kundu, IIT Kanpur	Action Taken
Recommendation from the auditor: Structure, Sequence and Contents of the M.Sc. (Mathematics) Curriculum. In my opinion it is very well structured. Suggestion I think in the first semester the Statistics and Probability course can be moved from the second semester, and the Algebra course may be moved to the second semester. It is just a small suggestion. Otherwise, the The program looks quite balanced. <u>Regarding the elective courses</u>, it might be better if some specific suggestions can be provided. It might be helpful to the students.	• P&S is one of the institute programme cores (for CSE, CCE, ECE) which is offered in the even semester. Therefore, This course has been placed in the second semester of M.Sc. (Mathematics). • The department offers a variety of elective courses whose list is given on the institute website. • Students are also given the opportunity to opt the courses offered from other departments (Engineering/Science).

Name of the Course: Program Audit Report M.Sc. Mathematics	
Name of the Auditor : Amiya Kumar Pani Name of Institution: BITS-Pilani,KK Birla Goa Campus	Action Taken

Recommendation from the auditor: The Core Course can be kept intact,but it needs to be compensate with appropriate choice of electives for following reasons: a. For Advanced higher study especially for advanced research b. To make students skilled for jobs in IT industries and other related industries where scientific computing is essential. How to choose electives: The elective courses should be from a part of hot topics in the job market say for example courses in mathematical data science, scientific computing and financial computing. Overall Comment: As far as possible, the minimum core courses are kept intact, but more useful electives will help them to choose a career for the products. The programme seems to be ok.	• The department offers a variety of elective courses whose list is given on the institute website. • Students are also given the opportunity to opt the courses offered from other departments (Engineering/Science).

Name of the Course: Program Audit Report M.Sc. Mathematics	
Name of the Auditor : Prof. B.S. Panda Name of Institution: IIT Delhi	Action Taken
Recommendation from the auditor: My suggestions are as follows: **Option I**: Change it to MSc Mathematics and Computing. And move functional analysis and Mathematical methods to electives. Include a course on Discrete Mathematics and another course on Data Structure and Algorithms. Introduce two more lab courses: Matlab toolbox and Python Programming. **Option II**: Keep it MSc Mathematics and Introduce specializations. Possible specializations: (i) Analysis (ii) Scientific Computing (iii) Theoretical Computer Science, (iv) Algebra and Number Theory and so on. Move functional analysis and Mathematical methods to electives. Include a course on Discrete Mathematics and another course on Data Structure and Algorithms as core	• Comments are appreciated. The suggested points need to be discussed at the separate department/Institute level committees.