

## TEACHING PLAN

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| <b>Course Title: Functional Analysis</b>   |   | <b>Duration of Examination: 3 hours</b> |
| <b>Course Code: MAMT- 301</b>              |   | <b>Maximum Marks: 100</b>               |
| <b>Course Instructor: Dr. Sanjay Kumar</b> |   |   |
| Unit I                                     |   |   |
| LECTURE 1                                  | Introduction, Metric spaces, examples                               |   |
| LECTURE 2                                  | Normed linear spaces, examples,                                     |   |
| TUTORIAL 1                                 | Exercises related to Lecture 1 and Lecture 2                        |   |
| LECTURE 3                                  | Banach Spaces and examples  |   |
| LECTURE 4                                  | Subspace of Banach space, Completion Theorem                        |   |
| TUTORIAL 2                                 | Examples and exercises related to Lecture 3 and Lecture 4           |   |
| LECTURE 5                                  | Properties of finite dimensional normed linear spaces and subspaces |   |
| LECTURE 6                                  | Equivalent norms  |   |
| TUTORIAL 3                                 | Examples and Exercises related to Lecture 5 and Lecture 6           |   |
| LECTURE 7                                  | Compactness, F. Riesz's Lemma                                       |   |
| LECTURE 8                                  | Linear operators, Inverse operator                                  |   |
| TUTORIAL 4                                 | Exercises related to Lecture 7 and Lecture 8                        |   |
| Unit II                                    |   |   |
| LECTURE 9                                  | Bounded linear operators  |   |
| LECTURE 10                                 | Continuous linear operators   |   |
| TUTORIAL 5                                 | Exercises and examples related to Lecture 9 and Lecture 10          |   |
| LECTURE 11                                 | Properties of bounded linear operators                              |   |
| LECTURE 12                                 | Relations between bounded and continuous linear operators           |   |
| TUTORIAL 6                                 | Exercises and examples related to Lecture 11 and Lecture 12         |   |
| LECTURE 13                                 | linear functionals and their properties                             |   |
| LECTURE 14                                 | Dual spaces   |   |
| TUTORIAL 7                                 | Exercise related to Lecture 13 and Lecture 14                       |   |
| LECTURE 15                                 | Duals of $\mathbb{R}, \mathbb{C}$                                   |   |
| LECTURE 16                                 | Dual of $l_p, 0 < p < \infty$                                       |   |
| TUTORIAL 8                                 | Exercises related to Lecture 15 and Lecture 16                      |   |
| Unit III                                   |   |   |
| LECTURE 17                                 | Hahn-Banach Theorem for real linear spaces, Complex linear spaces   |   |
| LECTURE 18                                 | Hahn-Banach Theorem for normed linear spaces                        |   |
| TUTORIAL 9                                 | Examples and exercises related to Lecture 17 and Lecture 18         |   |
| LECTURE 19                                 | Reflexive spaces  |   |
| LECTURE 20                                 | Uniform Boundedness Theorem, Baire's Category Theorem (statement)   |   |
| TUTORIAL 10                                | Examples and exercises related to Lecture 19 and Lecture 20         |   |
| LECTURE 21                                 | Strong and weak convergence   |   |
| LECTURE 22                                 | convergence of sequences of operators and functionals               |   |
| TUTORIAL 11                                | Examples and exercises related to Lecture 21 and Lecture 22         |   |
| LECTURE 23                                 | Open mapping Theorem  |   |
| LECTURE 24                                 | Closed Graph Theorem  |   |
| TUTORIAL 12                                | Examples and exercises related to Lecture 23 and Lecture 24         |   |
| Unit IV                                    |   |   |
| LECTURE 25                                 | Inner product spaces  |   |
| LECTURE 26                                 | Hilbert space, parallelogram Law                                    |   |
| TUTORIAL 13                                | Examples and exercises related to Lecture 25 and Lecture 26         |   |

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| LECTURE 27         | Orthogonal Complements and Direct Sums                      |
| LECTURE 28         | Orthonormal sets and Sequences                              |
| TUTORIAL 14        | Examples and exercises related to Lecture 27 and Lecture 28 |
| LECTURE 29         | Pythagorean Relation, Bessel's inequality                   |
| LECTURE 30         | Series related to orthonormal sequences and sets            |
| TUTORIAL 15        | Examples and exercises related to Lecture 29 and Lecture 30 |
| LECTURE 31         | Total orthonormal sets and sequences                        |
| LECTURE 32         | Separable Hilbert spaces                                    |
| TUTORIAL 16        | Examples and exercises related to Lecture 31 and Lecture 32 |
| Unit V             |   |
| LECTURE 33         | Legendre Hermite Polynomials                                |
| LECTURE 34         | Laguerre Polynomials  |
| TUTORIAL 17        | Examples and exercises related to Lecture 33 and Lecture 34 |
| LECTURE 35         | Riesz's Representation Theorem                              |
| LECTURE 36         | Hilbert adjoint operator                                    |
| TUTORIAL 18        | Examples and exercises related to Lecture 35 and Lecture 36 |
| LECTURE 37         | Properties of Hilbert adjoint operator                      |
| LECTURE 38         | Reflexive spaces  |
| TUTORIAL 19        | Examples and exercises related to Lecture 37 and Lecture 38 |
| LECTURE 39         | Self-adjoint operators                                      |
| LECTURE 40         | Unitary and normal operators                                |
| TUTORIAL 20        | Examples and exercises related to Lecture 39 and Lecture 40 |
| Total Lectures: 40 | Total Tutorials: 20                      Total = 60         |

**Text book:**

- Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, USA, 1989.

**Reference books:**

- George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill International editions.
- Martin Schechter, Principles of Functional Analysis, AMS, second edition, 2002.
- John B. Conway, A course in Operator Theory, AMS, 2000.
- Balmohan V. Limaye, Functional Analysis, New age International (P) Limited, Publishers, second edition, 1996.

