**MATH 343: RESEARCH DATA MANAGEMENT (L/P 45/0; CF 3.0)**

Course Purpose

To introduce the learner to the concept of rational database and the techniques and tools of developing and utilizing databases.

**Expected Learning Outcomes**

By the end of the course, the learner should be able to:

Explain the principles underlying rational database.

Design and develop a practical database.

Use structured query language (SQL) to access and manipulate data.

Generate pseudo random numbers

Tests randomness for pseudo-random number generators

**Course Content**

Database structures, data management systems, quality assurance, data confidentiality and security, key elements of effective reports, and preparation of clinical case report forms in Microsoft Access. Generation of tables, listing and graphs, the identification and reporting of data trends, and the generation of various types of study reports in Microsoft Excel and R. Development of the data management plan, coordination of data collection and capture, plan of the closure, archival of the study materials, data mining and project management activities. Pseudo-random number generators, Statistical tests for pseudo-random number generators

**Instructional Methods**

Presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. Jeffrey A. Hoffer, Ramesh Venkataraman, and Heikki Topi, 2022, Modern Database Management, 14th Edition.

2. Google Cloud Spanner, Google Cloud Platform documentation, updated regularly

3. S. K. Singh and S. R. Singh, 2023, Database System

4. Ray J. M. (2014). Research Data Management: Practical Strategies for Information Professionals; Purdue University Press.

7. Corti L., Veerle V.E., Woollard M. and Bishop L. 2014. Managing and Sharing Research Data: A Guide to Good practice: Sage Pub. Ltd.

8. Witten, I. H., and Frank, E. (2000). Data Mining. New York: Morgan-Kaufmann.

9. Elmasri R. and Navathi (2002). Fundamentals of database systems in business: Prentice hall.

10. Date C. J. (1997. An introduction to database systems: John Wiley & Sons, Inc.

11. Connolly T. and Beggy C. (2001). Database systems: A practical approach to design implementation and management: Heinemann.

**MATH 326: METHODS OF APPLIED MATHS I (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to introduce the learners and enhance their knowledge on methods and techniques on special functions or higher transcendental functions of great practical importance which are not considered in calculus courses.

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Derive the series solutions of the differential equations using Power series method,

Apply the Frobenius method to solve differential equations of first and second order.

Define Bessel`s equation and Bessel`s functions of order n and obtain the series representations of Bessel`s functions.

Define the Legendre’s differential equation and Legendre’s functions and use the recurrence relations of the Legendre’s equation to determine the Legendre’s polynomials.

Define the hyper geometric series and apply the knowledge to solve differential equations.

Express various functions in terms of Fourier series.

Solve differential equations using the method of separation of variables.

Determine the Laplace transforms and inverse Laplace transforms of various functions and use Laplace transforms to evaluate integrals of various functions.

**Course Content**

Series solution of second order linear ordinary differential equations. Bessel, Legendry and Hyper-geometric functions. Fourier series and applications. Methods of separation applied to second order partial differential equations. Laplace transformation and applications.

**Instructional Methods**

Presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. Amos Gilat and Vish Subramaniam, 2022, Numerical Methods for Engineers and Scientists: An Introduction with Applications using MATLAB, 4th Edition.
2. R. W. Hamming, (2020), Numerical Methods for Scientists and Engineers, 2nd Edition. Dover Publications Inc, New York.
3. Charles K. Chui (2019), Applied Mathematics: Data Compression, Spectral Methods, Fourier Analysis, Wavelets, and Applications.
4. Dennis G. Zill and Michael R. Cullen, 2023, Advanced Engineering Mathematics, Amazon, 5th Edition.
5. MIT Open Course Ware lecture notes in Mathematical Methods in applied mathematics, <https://mit.edu>.
6. Khan Academy interactive lessons and exercises on methods of applied mathematics, https://www.khanacademy.org
7. Riley, K. F. Hobson, M. B. and Bence, S. J. (2006), Mathematical Methods for Physics and Engineering: Computational techniques, and their applications, 3rd edition, Cambridge University Press, New York.
8. Dass, H.K. (2006)., Advanced engineering mathematics, New Delhi, 15th edition, S. Chand and company.

**MATH 324: DYNAMICS (L/P 45/0 C.F.3.0)**

**Course Purpose**

The purpose of this course is to enable learners understand the relationships between forces and motion and apply the knowledge to resolve any situation governed by them.

**Course Outcomes**

By the end of the course, the learner should be able to:

Apply the knowledge and skills of moving bodies to solve problems involving movement of particles in two and three dimensions

Determine the coordinates of a point in space using the moving co-ordinate axes

Convert coordinates from one system to another to appropriately solve real-life problems

Determine the center of mass and moment of inertia of rigid bodies

Evaluate the maximum or minimum value of a definite integral involving certain functions and functional.

Derive and demonstrate the applications of Lagrange’s equations and Hamilton- Jacobi equation in solving real life problems.

**Course Content**

Motion of particles in two and three dimensions. Coordinate systems and transformation. Rigid body dynamics, Calculus of variations, Lagranges equations, Hamilton’s principle and Hamilton- Jacobi equations.

**Instructional Methods**

Lectures, presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials and Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. Stephen T. Thornton and Jerry B. Marion, 2021, Classical Dynamics of Particles and Systems, 5th Edition.
2. David Tong (2019). Introduction to Dynamics: A New Perspective,
3. Meriam J. L., and L. G. Kraige, 2021, Engineering Mechanics: Dynamics, 8th Edition.
4. MIT OpenCourseWare lecture notes in dynamics, <https://mit.edu>
5. Khan Academy interactive lessons and exercises on classical mechanics and dynamics, https://www.khanacademy.org
6. Frank, A. and Elliot, M. (2008). *Schaum’s Outline of Fluid Mechanics, 5th Edition*; McGraw-Hill Companies.
7. Robert C. Wrede, Murray R. Spiegel, (2002). Fluid Mechanics, 2nd edition McGraw-Hill Companies.

**MATH 390: RESEARCH METHODOLOGY (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to equip the learner with research skills and therefore apply them in different areas of interest especially of scientific nature.

**Expected Learning Outcomes**

By the end of the course, the learner should be able to:

Discuss and identify tools of research and sources of research information.

Review some literature and identify gaps in research work.

Discuss and Critique published results.

Develop appropriate objectives and justification for a given research problem.

Prepare a research proposal with appropriate title, abstract, introduction, literature review, methodology, hypothesis, budget and references.

Make a presentation of a research work.

**Course Content**

Research: definitions, types and basic concepts; tools of research and sources of information.

Literature review and identification of gaps in knowledge.

Critiquing published results and Empirical research planning: objectives and justification. Problem identification; Proposal preparation. Identification of appropriate methodology; Logic of scientific inquiry: Testing hypotheses. Budgeting. Ethical issues.

Research presentation: Title and authors, abstract, introduction, literature review, methodology, results, discussion, conclusions and references. Monitoring and evaluation of projects, Writing a concept paper, writing a project report and the oral presentation skills.

**Instructional Methods**

Lectures, presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. John W. Creswell and J. David Creswell, 2018, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 5th Edition.
2. Kothari , C.R., 2016, Research Methodology: Methods and Techniques, 4th Edition, 2016.
3. Uma Sekaran and Roger Bougie, 2021, Research Methods for Business: A Skill-Building Approach, 8th Edition.
4. Ranjit Kumar, 2021, Research Methodology: A Step-by-Step Guide for Beginners, 5th Edition.
5. John W. Creswell and Cheryl N. Poth, 2017, Qualitative Inquiry and Research Design: Choosing Among Five Approaches, 5th Edition.
6. Mark Saunders, Philip Lewis, and Adrian Thornhill, 2019, Research Methods for Business Students, 8th Edition.
7. Norman K. Denzin and Yvonna S. Lincoln, 2017, The SAGE Handbook of Qualitative Research, 5th Edition.

**MATH 407: FOURIER ANALYSIS (45/0 C.F. 3.0)**

**Course Purpose**

The purpose of this course is to give students an understanding of discrete Fourier series and integral Fourier and inverse-Fourier transforms, and provide students with practice in their application and interpretation in a range of situations.

**Expected Learning Outcomes**

By the end of the course, the learner should be able to:

Evaluate and apply integral expressions for the forwards and inverse Fourier transform to a range of non-periodic waveforms.

Calculate the Fourier transform or inverse transform of common functions.

Construct a Fourier transform of a Gaussian function to produce another Gaussian function (of differing width and amplitude).

Discuss fundamental mathematical properties of Fourier transform like linearity, shift, symmetry, scaling, modulation and convolution.

Describe the defining properties for the Dirac delta function and apply the sifting property of delta functions.

Calculate the Fourier transform of periodic functions including the cosine, sine and Dirac comb functions.

Express a convolution mathematically and explain its function and relationship to measurement processes.

Apply Parseval's Theorem and to know about its physical significance in terms of the power of the Fourier components.

**Course Content**

Boundary value problems: Mathematical formulation and solution of physical problems. Definitions pertaining to partial differential equations. Linear partial differential equations. Some important partial differential equations. the Laplacian in different coordinate systems. Methods of solving boundary value problems. Fourier series and applications: the need for Fourier series. periodic functions. piecewise continuous functions. Definition of fourier series. Dirichlet conditions. odd and even functions. half-range Fourier sine or cosine series, Parseval's identity, uniform convergence, integration and differentiation of Fourier series, complex notation for Fourier series, double Fourier series, applications of Fourier series, functions: definitions involving orthogonal functions. orthonormal sets. orthogonality with respect to a weight function, expansion of functions in orthonormal series. Gamma, Beta and other special functions: special functions, the gamma function, the beta function, other special functions. asymptotic series or expansions. Fourier integrals and applications: the need for Fourier integrals, the Fourier integral, equivalent forms of Fourier’s integral theorem. Fourier transforms, Fourier sine and cosine transforms, Parseval's identities for Fourier integrals, the convolution theorem for Fourier transforms, applications of Fourier integrals and transforms.

**Instructional Methods**

Lectures, presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. Brad Osgood., (2020), Fourier Analysis and Its Applications.

2. David W. Kammler., (2017), A First Course in Fourier Analysis.

3. Fraser J. M., and Ramsay K.D., (2022), Fourier Analysis of Weighted Fractals, Canadian Mathematical Bulletin.

4. MIT OpenCourseWare lecture notes on Fourier analysis, <https://mit.edu>

5. Khan Academy interactive lessons and exercises on Fourier analysis, https://www.khanacademy.org

6. Terras, A., (1988), Harmonic Analysis on Symmetric Spaces and Applications, I, II, Springer Verlag.

7. Strichartz, R., (1994), A Guide to Distribution Theory and Fourier Transforms, CRC Press.

8. Dym, H. and H. P. McKean, (1972), Fourier Series and Integrals, Academic Press.

9. Bracewell, R. N. (1986), The Fourier Transform and its Applications, McGraw Hill.

10. James, J. F. (2002), A Student’s Guide to Fourier Transforms, 2nd ed., Cambridge.

11. David W. Kammler, (2000), A First Course in Fourier Analysis, Prentice hall.

**MATH 427: PARTIAL DIFFERENTIAL EQUATIONS II**

**Course Purpose**

The purpose of this course unit is to provide insight into more advanced applied mathematics. It is also designed to fill the gaps left in the development of Partial differential Equations I.

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Identify linear and semi linear pde`s of the second order.

Classify partial differential equations into either hyperbolic, parabolic or elliptic types using the method of characteristics

Apply the D` Almberts Method to solve partial differential equations of the second order

Apply the D Operator method to Solve linear homogeneous and non homogeneous partial differential equations of the nth order with constant co efficient.

Apply the Riemann’s method, Separation of Variables and the Method of characteristics to solve the heat equation, Vibrating string / wave equation, Two dimensional heat flow equation, Laplace equation / vibrating membranes and the Transmission line equations.

**Course Content**

linear and semi linear Pde`s of the second order, Characteristics of linear and semi-linear partial differential equations of the second order, Boundary value and initial value problems, D` Almberts Method, the D Operator method, Riemann’s method, Separation of Variables and the Method of characteristics, the heat equation, Vibrating string / wave equation, Two dimensional heat flow equation, Laplace equation / vibrating membranes and the Transmission line equations.

**Instructional Methods**

Lectures, presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. Walter A. Strauss, (2020), Partial Differential Equations: An Introduction.

2. Mark S. Gockenbach, (2018), Partial Differential Equations: Analytical and Numerical Methods,

3. Dennis G. Zill and Michael R. Cullen, (2023), Advanced Engineering Mathematics, 5th Edition.

4. MIT OpenCourseWare lecture notes in Pdes, <https://mit.edu>

5. Khan Academy interactive lessons and exercises on Pdes, <https://www.khanacademy.org>

6. Stanley Farlow (1993), Partial Differential Equations for Scientists and Engineers, Dover

7. Richard Haberman (2003), *Applied Partial Differential Equations*,4th Ed, Prentice-Hall

8. Walter Strauss, (1992) Partial Differential Equations: An Introduction,Wiley

9. Chapra S. C and R.P (2001). *Canale Numerical Methods for Engineers,* 6th edition, McGraw-Hill

10. Birkhoff, G. and Rota. G.C, (1978), *Ordinary Differential Equations*, 3rdEd,Wiley.

**MATH 428: MATHEMATICAL MODELLING**

Course Purpose

The purpose of this course is to equip the learner with Mathematical representation, treatment and modeling of Physical and biological processes, using a variety of applied mathematical techniques and tools.

**Expected Learning Outcomes**

By the end of the course, the learner should be able to:

Analyse Nonlinear Systems for steady state solutions

Discuss and identify the various types of Bifurcations

Discuss and develop a Lyapunov functions and the Centre Manifold theorem.

Develop simple models in engineering, social sciences, health sciences and business

Discuss the SIR epidemic model and simple extensions

Calculate the Reproduction Number by the next generation matrix and other methods.

Simulate the developed models using appropriate computer Soft wares (R Software and Python)

Discuss recent trends in Mathematical Modeling.

**Course Content**

Introduction to Nonlinear Systems - Analysis of nonlinear systems, Main tools for analysis of nonlinear systems   
Equilibrium points - Stability, Linearization and Stability,- Linearization and Classification of equilibrium points

Liapunov functions, Liapunov Theorem for continuous case, Invariant sets ,Bifurcations and Manifolds,- Types of Bifurcations,   
Hopf Bifurcation, Population dynamics, Population interactions,- Predator-Prey interactions,- Competing species,- Mutualism/Symbiosis; Historical development of mathematical theories and models for growth of one-species populations (logistic and off-shoots), including considerations of age distributions (matrix models, Leslie and Lopez; continuous theory, renewal equation); Mathematical theories of two and more species systems (predator-prey, SIR models, competition, symbosis; leading up to present-day research, the reproduction number, chemical kinetics, Machine learning and artificial intelligence in modeling.

**Instructional Methods**

Lectures, presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. Kuznetsov Y.A., Petrov, A.P. and Korolkova, A. S., (2022), Mathematical Modeling: Models, Analysis and Applications.
2. Elizabeth S. Allman, John A. Rhodes, 2021, Mathematical Models in Biology.
3. Sarah P. Otto, and Troy Day, 2020, Mathematical Models for Society and Biology.
4. Andrei D. Polyanin and Alexander V. Manzhirov, 2022, Mathematical Modeling: Applications with GeoGebra.
5. Fred Brauer, Carlos Castillo-Chavez, and Zhilan Feng, 2019, Mathematical Modeling in Epidemiology.
6. Brian P. Ingalls, 2013, Mathematical Modeling in Systems Biology: An Introduction.
7. Frank R. Giordano, Maurice D. Weir and William P. Fox, 2013, A First Course in Mathematical Modeling
8. Kai Velten, 2010, Mathematical Modeling and Simulation: Introduction for Scientists and Engineers.
9. May R.M. 1981, *Theoretical Ecology. Principles and Applications*. Blackwell Scientific Publications, Oxford, second edition.

**MATH 426: METHODS OF APPLIED MATHS II (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to enable learners apply the various methods and techniques on special functions or higher transcendental functions of great practical importance for modelling Course Purposes.

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Prove the orthogonality of Bessel Functions and determine its generating functions

Determine the Bessel integral and the Fourier Bessel expansion

Apply Bei, Ber and Gamma functions in solving engineering problems.

Prove the orthogonality of legendre polynomials and determine its generating functions.

Apply laplace transform methods to Solve Fredholm and voltera integral equations.

Apply algebraic operations on tensors.

Apply Fourier transforms to solve ode and pde problems.

**Course Content**

Special Functions; Further concept in special functions, generating functions, modified Bessel functions, Associated Legendre Functions, orthogonality of legendre polynomials, Bei, Ber and Gamma functions, Integral equations; Fredholm and Volterra equations including Laplace transform methods. Catesian tensors. Definition of Algebra of tensors. Quotient Law, Metric Tensor. Fourier Transform and applications.

**Instructional Methods**

Lectures, presentations, Group discussions & assignments, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens, computers with mathematical soft wares installed.

**Course Assessment**

CATs and Assignments 40%,

Final examinations 60%,

Total marks 100%

**Recommended Reading/Materials/References**

1. Dennis G. Zill and Michael R. Cullen, 2023, Advanced Engineering Mathematics, 5th Edition.
2. MIT OpenCourseWare lecture notes in Mathematical Methods in applied mathematics, <https://mit.edu>
3. Khan Academy interactive lessons and exercises on methods of applied mathematics, https://www.khanacademy.org
4. Riley, K. Hobson, M. and Bence, S. (2006). Mathematical Methods for Physics and Engineering, 3rd edition, Cambridge University Press, NY.
5. Alan, J. (2002). Advanced Engineering Mathematics, Harcourt Academic Press.
6. Glyn, James. (2011). Advanced Modern Engineering Mathematics, 4th edition, Prentice Hall.
7. Bourne, D.E. and Kendall, P.C. (1992). Vector, Analysis and Cartesian Tensors, 3rd ed., Chapman and Hall, London.
8. Dass, H.K. (2006). Advanced engineering mathematics, New Delhi, 15th edition, S. Chand and company.
9. Bill, C. (2001). Understanding engineering mathematics, Newnes, Oxford.
10. Chan, C.F, Man F. and kee, D. (2003). Advanced Mathematics for Engineering and Science, World scientific, London