PROGRAMME PROJECT REPORT
MASTER OF SCIENCE IN MATHEMATICS
OF
ONLINE PROGRAMMES

Name of the Programme: Master of Science in Mathematics

Eligibility: Graduate with Mathematics

Minimum Duration: 2 Years (4 Semesters)

Maximum Duration: 4 Years

(i) **Programme's mission and objectives:**

The program mission is tofoster in mathematical education and research, technical excellence, well poised between abstraction and application

The programme Objectives of Masters of Science (Mathematics) can be enumerated as

- Building the confidence of the students by emphasizing on domain knowledge so that they can contribute responsibly in the Computation field.
- Creating an option of working in Industry.
- Pursuing higher education for a career in teaching and research

(ii) **Relevance of the program with HEI's Mission and Goals:**

The vision and mission of the Centurion University of Technology and Management are:

Vision:
A globally accredited human resource center of excellence catalyzing "sustainable livelihoods" in the "less developed markets across the globe".

Mission

- Provision of quality, globally accredited academic programmes in technology and management.
- Provision of globally accredited employability training for less endowed segments of the population.
- Promotion of entrepreneurial culture and enterprise in the target areas.
- Facilitating improved market access to goods and financial services to the target population.
- Promotion of lighthouse project interventions in the target area.

The proposed programme is in sync with the mission of the University to develop quality programmes in the field of Applied Sciences. This programme will help in creating culture in the eastern India in general and Odisha in particularly. The candidates with research mind set will be nurtured and incubated to become successful researcher.

The vibrant academic environment is nurtured by strongly motivated faculty and provides an opportunity to pursue research in front line areas of basic sciences as well as in interdisciplinary areas of science and technology. In the coming decade, apart from the existing areas, the

department intends to develop areas related to mathematical aspects of computing science in all its manifestations.

(iii) **Nature of prospective target group of learners**:

The curriculum of the programme is designed after understanding the diverse needs of the students and the industry in India. While conceptualizing the programme, several brainstorming sessions are done with academia, existing students and alumni of the University. Based on the suggestions of all stakeholders, the final programme is evolved considering the requirement of students from rural areas and employees of different organizations in pursuit of acquiring quality higher degrees with low level of disposable income. Centurion University is one of the pioneers in using online learning platform for conducting classes and handling examination on time without deviating the academic schedule during this pandemic. Students of Eastern India particularly rural area will be joining the online programme due to provision on internet connectivity, less travel and relocation cost and less academic fee as well.

(iv) **Appropriateness of programme to be conducted in Open and Distance Learning and/or Online mode to acquire specific skills and competence:**

The learning outcomes specified below for the M.Sc. Mathematics programme can be appropriately developed through Open and Distance Learning and/or Online mode. The learning outcomes are to

- Exhibit knowledge and skills on Mathematical Sciences
- Formulate the model and finding the solution using advanced tools.
- Demonstrate critical-thinking and problem-solving skills
- Recognize the need for change, act as change agent and adapt to change
- Carry out research activities either independently or in a team.

These learning outcomes are embedded in the courses to enrich the knowledge and skills of the graduates opting for the programme.

(v) **Instructional Design:**

1. Title of the Programme: Master of Science in Mathematics
2. Minimum Duration of the Programme: 2 Years (4 Semesters)
3. Maximum Duration of the Programme: 4 Years
4. Whether Listed in Section (22) of UGC Act: Yes
5. Level of the Programme: M.Sc. Mathematics I, M.Sc. Mathematics II
6. Eligibility: Graduate with Mathematics
7. Optional Early Exit Certification: Not Applicable
8. Lateral Entry: Not Applicable

9. Grading Scale:

The grading scale of the University will be in accordance with University norms. A letter grading system is followed in CUTM. A Nine Point grading system on base of 10 is followed in CUTM as per the below mentioned table.

Sl. No.	Qualification	Grade	Score on 100 Percentage Points	Point
1	Outstanding	"O"	90 & above up to 100	10
2	Excellent	"E"	80 & above but less than 90	9
3	Very Good	"A"	70 & above but less than 80	8
4	Good	"B"	60 & above but less than 70	7
5	Fair	"C"	50 & above but less than 60	6
6	Below Average	"D"	40 & above but less than 50	5
7	Failed	"F"	Below 40	0
8	Malpractice	"M"	-----	0
9	Absent	"S"	----	0

Grade C shall be considered as average, Grade D shall be pass Grade for theory and Grade C shall be Pass Grade for Practical/ Sessional/ Project/ Seminar.

All examinations related information will be available in the website.

10. Admission Procedure:

10.1 Admission of M.Sc Mathematicsprogramme of study shall be made on Merit.

10.2 Admission cannot, however be claimed by any candidate as a matter of right. The admission and or re-admission of a candidate shall be entirely at the discretion of the University which may refuse to admit any student without assigning any reason therefor.

10.3 On selection for admission to the programme,the candidate shall, within the time fixed by the Dean/ Director deposit the fees prescribed for the programme. If the candidate fails to deposit feeswithin the stipulated time, the selection shall automatically stand cancelled. Such a candidate shall not be admitted to the concerned programme unless a fresh order of selection and extension of date forpayment of fees is issued.

10.4 Thecandidates other than the domicile of Odisha are required to fulfil the entry criteria as prescribed by the Government of Odisha time to time.

11. Personal Contact Programme (PCP) and Assignment:

PersonalContact Programmes (PCP) shall be organized by the University for the course. During these sessions, faculty help students with the course work. These contact classes are not meant for covering the curriculum. The faculty are there to help and guide the students with regards to their course difficulties. It would be in the interest of students to attend all the contact classes. The PCP will include problem solving sessions, interaction sessions, practical, counselling sessions, self-study methods etc. The schedule of PCP for course will be announced and update on university website. The key of conducting these PCP will be to

enhance the skill sets of students under Open Distance Learning and make them employable in a better way.

12. Examination and Result:

12.1 The distribution of continuous internal assessment and Term End Examination of the programme will be in accordance with the rules and regulations made by Quality and Assurance Cell of the University.

12.2 Resultwill be displayed on the official website of the University. The Statement of Grades will be issued by the Examination Cell

12.3 Studentscan apply for Re-Checking/ Re-Evaluation on demand as per the procedure in practice from time to time.

12.4 Students with backlog examination can apply for Examination on Demand (EoD) as per university norms.

(a) Curriculum Design:

Course Structure

Sl.no	Course	Credits
1.	Core Course	64
2.	Domain	20/26
3.	Skill	12/06
4.	Total	96

Core Courses

Sl.No	Code	Subject Name	Cerdit	Course Type (Th+Pr+Pj)
1	CUON1525	Heat and Mass Transfer	4	2+1+1
2	CUON1526	Numerical Methods for CFD	4	2+1+1
3	CUON1527	Fluid Dynamics	4	3+1+0
4	CUON2380	Grid Generation And CFD Simulation Using Simulia	4	0+2+2
5	CUON2378	Research Methodology & IPR	4	2+0+2
6	CUON1530	Advanced differential equations	4	2+1+1
7	CUON1531	Graph Theory	4	3+1+0
8	CUON1532	Optimization techniques	4	3+1+0
9	CUON1533	Advanced Statistical Methods	4	2+1+1
10	CUON1534	Applied Number Theory	4	3+1+0
11	CUON1535	Advanced complex analysis	4	3+0+1
12	CUON1536	Topology	4	3+0+1
13	CUON1537	Differential Geometry	4	3+0+1
14	CUON1538	Advanced Algebra	4	3+0+1

15	CUON1018	Data Analysis and Visualization using Python	4	0+1+3
16	CUON1019	Machine Learning using Python	4	1+2+1
		Total	64	

Note:

- Student can opt for elective or domain area courses only in the 2nd year.
- All the courses will be offered in Theory, Practice and Project mode
- 1 credit theory= 10 hours online class engagement, 1 credit Practice/Project = 15 hours engagement of student

DOMAIN COURSES

(i) Computational Fluid Dynamics

	Computational Fluid Dynamics	**20**	**2+10+8**
CFON2180	Introduction to CFD	3	2+0+1
CFON2181	Grid Generation	2	0+2+2
CFON2182	Flow Solver Techniques-Simulia	4	0+3+1
CFON2183	Simulation and Validation	5	0+5+0
CFON2184	Industry Specific Project	6	0+0+6

(ii) Data Science and Machine Learning

	Data Science and Machine Learning	**26**	2+9+15
MLON2010	ML for Predictive Analysis	4	0+2+2
MLON2011	ML for Image Analytics	4	0+2+2
MLON2007	Digital video Processing	3	0+2+1
MLON2009	Mathematics for ML	3	2+1+0
MLON2008	IoT Analytics	4	0+2+2
MLON2005	Internship	4	0+0+4
MLON2006	Project	4	0+0+4

(iii) NET Domain

Sl.No	**Code**	**Subject Name**	**Cerdit**	**Course Type** (Th+Pr+Pj)
1	NTON2480	Functional Analysis	4	3-0-1
2	NTON2481	Integral Equation	4	3-0-1
3	NTON2482	Advanced Calculus	4	3-0-1
4	NTON2483	Operation Research	4	3-0-1
5	NTON2484	Descriptive statistics & Data analysis	4	3-0-1
		Total	20	

(b) Detailed syllabi

Course outline

CUON1525 HEAT AND MASS TRANSFER

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
HEAT AND MASS TRANSFER	CUON1525	Theory+Practice+Project	2-1-1	Nil

Objective

- To understand the basic concepts and mechanisms of heat and mass transfer under steady state and transientconditions.

Course outcome

COs	Course outcomes
CO1	• Explain fundamental concepts of heat transfer
CO2	• Apply heat conduction equations to different surface configurations under steadystate and transient conditions and solveproblems.
CO3	• Explain basic laws for radiation and apply these principles to radiative heattransfer between different types of surfaces to solveproblems.
CO4	• Apply diffusive and convective mass transfer equations and correlations to solve problems for differentapplications.
CO5	• Apply free and forced convective heat transfer correlations to internal andexternal flows through/over various surface configurations and solveproblems.

Course outline

CUON1525 Heat and Mass Transfer (2-1-1)

Module I (T-3 Hrs.+P-2Hrs.)

Introduction to heat transfer: Heat Transfer Mechanisms

Conduction:

Fourier's Law of Conduction, General Heat Conduction Equation in Different Coordinate Systems (No Derivation), One Dimensional Steady State Conduction in Plane Wall, Conduction with Internal Heat Generation.

Practice 1: To find the thermal conductivity of a material by the two slabs guarded hot plate method.

Assignment 1: Assignment on Conduction.

Module II (T-2Hrs.+P-2Hrs.)

Fins and TransientConduction:

Overall Heat Transfer Coefficients, Unsteady State Heat Conduction, Lumped Heat Capacity System and Lumped Capacitance Method.

Practice 2: To find the thermal resistance of the sample.

Assignment 2: Assignment on Fins and Transient Conduction.

Module III (T-4 Hrs.+P-4Hrs.)

Convection:

Thermal Boundary Layer, Principles and Governing Equations, Forced Convection: External Flow over a Flat Plate, Internal Flow Through Pipe, Natural Convection: Vertical&Horizontal Surfaces.

Practice 3: To determine the overall heat transfer coefficient at the surface of a given vertical metal cylinder by the natural convection method.

Practice 4: To verify Newton's Law of Cooling of different materials and different liquids.

Assignment 3: Assignment on Convection.

Module IV (T-2 Hrs.+P-2Hrs.)

Heat Transfer with Phase Change Film Wise and Drop Wise Condensation, Boiling Heat Transfer, Regimes of Boiling.

Module V (T-2 Hrs.+P-2Hrs.)

Heat Exchangers:

Types of Heat Exchangers, Heat Exchanger Analysis, LMTD, Overall Heat Transfer Coefficient, Heat Exchanger Effectiveness, NTU.

Practice 5: Determination of Effectiveness and Efficiency of Parallel Flow and Counter Flow Heat Exchanger.

Assignment 4: Assignment on Heat Exchangers.

Module VI (T-4 Hrs.+P-2Hrs.)

Radiation:

Black Body Emission, Emissive Power, Laws of Radiation, Nature of Black Bodies, Radiation Shape Factor, Radiation Heat Transfer Between Two Surfaces.

Practice 6: To find the emissivity of different material surface.

Assignment 5: Assignment on Radiation.

Module VII (T-3 Hrs.+P-2Hrs.)

Mass Transfer:

Introduction, Analogy between heat and mass transfer, Mass diffusion, Fick's law of diffusion, boundary conditions, Steady mass diffusion through a wall, Mass convection.

Assignment 6: Assignment on Mass Transfer.

TextBooks:

1. Mahesh M. Rathore, Engineering Heat Transfer , Jones & Bartlett Learning,2011
2. Yunus A. Cengel & Afshin J. Ghajar, "Heat and Mass Transfer-Fundamentals and Applications", McGraw Hill, 5th Edition2015
3. Yunus Cengel, Heat And Mass Transfer: Fundamentals And Applications, McGraw-Hill Higher Education,2014

Reference Books:

1. R.C Sachdeva, Fundamentals of Heat and MassTransfer
2. R.K. Rajput, Heat Transfer, LaxmiPublication

CUON1526 NUMERICAL METHODS FOR CFD

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
NUMERICAL METHODS FOR CFD	**CUON1526**	**Theory + Practice + Project**	**2-1-1**	**Nil**

Objective

- To learn fundamentals of computational methods like FDM and FVM for solving linear and non-linear partial differential equations related to fluid dynamics and heat transfer.

Course outcome

COs	Course outcomes
CO1	• Explain basic concepts of CFD
CO2	• Overall idea of the governing equations
CO3	• Assess the principles of numerical analysis and concepts of consistency, stability,and convergence.
CO4	• Evaluate finite difference/volume schemes on model problems of computational fluid dynamics.
CO5	• Construct program-code using Python to obtain numerical solutions of partial differential equations, relevant to Computational FluidDynamics.

Course Outline

CUON1526 Numerical Methods for CFD (2-1-1)

MODULE I

Introduction to CFD: Basics of computational fluid dynamics, Definition and overview of CFD- need, advantages, problem areas, Governing equations of fluid dynamics –

Continuity, Momentum and Energy equations, Non-Dimensional form of these governing equations, Classifications of PDE: Elliptic, Parabolic and Hyperbolic equations.

MODULE II

Finite Difference Method (FDM): Derivation of Finite difference equations (FDE) of 1^{st} and 2^{nd} order derivatives using Taylor series expansion. Explicit method-FTCS Method,

Implicit method-BTCS Method, Crank-Nicholson method, Error, Convergence and stability analysis of above numerical Scheme, Keller Box Method.

MODULE III

Solution of Simultaneous Equations: Direct and Iterative methods; Gauss-elimination, Gauss-Jordan, Gauss-Jacobi and Gauss-Seidel methods, Tri Diagonal Matrix Algorithm (TDMA) (Thomas)

Practice 1: Gauss-elimination method using Python

Practice 2: Gauss-Seidel method using Python

Practice 3: Tri Diagonal Matrix Algorithm using Python

Project 1: Solution of Simultaneous Equations using Gauss-Jordanmethod.

Project 2: Solution of Simultaneous Equations using Gauss-Jacobimethod.

MODULE IV

Application of FDM: Solutions of

Elliptic PDE:One-and Two-dimensional steady heat conduction, Laplace's Equation, Poisson's equation

Parabolic PDE: Unsteady heat conduction, Stoke's 1^{st}& 2^{nd} Problems.
Hyperbolic PDE: One-dimensional wave equation

Practice 4: Solution of One-dimensional steady heat conduction using Python.

Practice 5: Solution of Laplace's equation using Python.

Practice 6: Solution of Unsteady heat conduction using Python.
Practice 7: Solution of One-dimensional wave equation using Python.
Practice 8: Solution of Stoke's Problem.

Project 3: Solution of Poisson's equation.

Project 4: Solution of Burger's equation.

MODULE V

Finite Volume Method (FVM):
Fundamentals of FVM, Integral Form of 1-D Conservation equation, Finite Volume Method in2-D

MODULEVI

Application of FVM: Solutions of1-D steady state Diffusion and Convection equations.

Project 5: Solutions of1-D steady state Diffusion equation.

MODULE VII

Application of FVM: Solutions of 2-D steady state Diffusion and Convection equations.

Project 6: Solutions of2-D steady state Convection equation.

Text Books:

1. Computational Fluid dynamics by JohnD.Anderson,Jr
2. Computational Fluid dynamics and Heat Transfer , by John C. Tannehill , Dale A.Anderson , Richard H.Pletcher

3.Introduction to finite elements in engineering, by Tirupathi R. Chadraupala, Ashok D. Belegundu, Chapter .3

4.An introduction to computational fluiddynamics, by HKVersteeg and WMalalasekera, Chapter4,5

Course outline

CUON1527FLUID DYNAMICS

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
FLUID DYNAMICS	**CUON1527**	**Theory**	**3-0-1**	**Nil**

Objective

- To introduce the foundations of fluid dynamics, various formulations of governing equations and their mathematical properties in order to establish a firm basis for other modules.

Course outcome

COs	Course outcomes
CO1	• Comparative analysis on different types of flow
CO2	• Explain mass, momentum and energy conservation and their mathematical equations in different physical situations.
CO3	• Distinguish and analyse the governing equations of fluid dynamics in various formulations for compressible and incompressible viscous and inviscidflows.
CO4	• Estimate the impact of different physical phenomena based on dimensionalanalysis.
CO5	• Examine mathematical properties of governing equations and be able tocritically evaluate correct boundary/initial value problems for variousflows.

Course Outline

CUON1527 Fluid Dynamics (3-0-1)

MODULE – I (4hr+0hr+2hr)

Kinematics of Fluids, Methods describing Fluid motion, Lagrangian and Eulerian Methods, Translation, Rotation and Rate of Deformation, Streamlines, Path lines and Streak lines.

PROJECT 1: A Report on Steady vs Unsteady Flow, Compressible vs incompressible Flow, Laminar vs Turbulent Flow, Newtonian vs Non-Newtonian Flow, Invisid vs Viscous Flow, Rotational vs Irrotational Flow. (Definition, Comparative Study & Examples)

MODULE – II (5hr+0hr+0hr)

Fundamental equations of the flow of viscous compressible fluids: Equations of continuity**,** motion and energy in Cartesian coordinate systems, The equation of state, Fundamental equations of continuity, motion and energy in Cylindrical & Spherical coordinate systems.

MODULE – III (4hr+0hr+2hr)

2-D and 3-D inviscid incompressible flow: Basic equations and concepts of flow, Circulation theorems, Velocity potential, Rotational and Irrotational flows, Bernoulli's Equation.

PROJECT 2: A study on Stokes Circulation Theorem

MODULE – IV (4hr+0hr+8hr)

Laminar Flow of Viscous Incompressible Fluids: Flow between parallel flat plates:Couette flow, Steady Flow in pipes: Hagen-Poiseuille flow, Unsteady motion of a flat Plate.

PROJECT 3: A study on plane Poiseuille flow.

PROJECT 4: A report on steady flow of viscous incompressible fluid between two porous parallel plates.

PROJECT 5: A study on laminar flow between two coaxial circular cylinders (i.e. an annulas).

PROJECT 6: A report on unsteady flow of a viscous incompressible fluid over an oscillating plate.

MODULE – V (5hr+0hr+0hr)

The Laminar boundary layer Flow: Properties of Navier-Stokes equations, Boundary layer equations in 2-D flow, Similarity of Flows, Reynold's Number, The boundary layer along a flat plate, Boundary layer on a surface with pressure gradient.

MODULE – VI (4hr+0hr+0hr)

Momentum Integral theorems for the boundary layer, Von karman-Pohlhausen method, Separation of boundary layer flow, Boundary layer control.

MODULE – VII (4hr+0hr+0hr)

The origin of Turbulence, Reynold's modification of the Navier-Stokes equations for Turbulent flow, Reynold's stresses, Prandtl's mixing length theory.

BOOK PRESCRIBED

1. S. W. Yuan, "Foundations of Fluid Mechanics", Prentice – Hall of India

Chapters: 3 (3.1 to 3.4), 5 (5.1 to 5.6), 7 (7.1 to 7.5), 8(8.1, 8.3, 8.4, 8.8),9 (9.1 to 9.6, 9.8, 9.9), 10(10.1 to 10.3(a))

BOOK REFERENCE

1. J. L. Bansal , “Viscus Fluid Dynamics”, IBH Publication,Joypur.
2. M. D. Raisinghania, "Fluid Dynamics with Complete Hydrodynamics", S. Chand & Company Ltd, NewDelhi.

Course outline

CUON2380 GRID GENERATIONAND CFD SIMULATIONUSING SIMULIA(0-2-2)

Subject Name	Code	Type of course	T-P-P(Credit)	Prerequisite
GRID GENERATIONAND CFD SIMULATION USING SIMULIA	**CUON2380**	**Practice + Project**	**0-2-2**	**Nil**

Objective

- To introduce the concepts of grid generation required for Computational Fluid Dynamics applications providing hands-on experience using Simulia.
- To produce a CFD simulation in order to generate an exact picture of a particular flow problem in various engineering fields.
- To apply for resolving different fluid flow related problems like flow velocity, density, temperature, and chemical concentrations for any area where flow is present.

Course outcome

COs	Course outcomes
CO1	• Evaluate the requirements of grid generation for Computational Fluid Dynamics applications.
CO2	• Understand the construction techniques of structured and unstructured grids using Simulia.
CO3	• Assess the control and efficiency of grid generationprocedures.
CO4	• To apply CFD simulation in various industries in order to achieve flawless product designs using computationaltools.

CO5	• To apply CFD simulation in various industries in order to achieve flawless product designs using computationaltools.

Course Outline

Grid Generation &CFD Simulation using Simulia(0-2-2)

Practice: 2Hrs.
Project: 4Hrs.

Practice 1. Getting Started with the 3DExperience Platform.

Practice 2.CFD analysis of steady-state internal Laminar Pipe flow.

Practice 3. Grid generation for pipe at Re=500.

Project 1. Analysis of pipe flow at Re= 500.

Practice 4.3D Coarse/ Medium/ Fine unstructured mesh for Aerofoil.

Practice 5.CFD analysis Steady-state external flow over an Airfoil.

Project 2. Estimation of Drag and lift coefficients in the flat plate at Re=10,000.

Practice 6. Grid Independence study for the above cases (pipe/airfoil) using different solver schemes.

Practice 7. Generation of 3D mapped meshing for Cylinder.

Project 3. Flow analysis over a circular cylinder at Re=10^7.

Practice 8. Grid generation for cross flow heat exchanger.

Project 4. Temperature analysis through cross-flow heat exchanger.

Practice 9. Generation of 3D Mesh for Ahmed Body.

Project 5. Turbulent analysis of Ahmed body.

Practice10. Grid generation for turbulent flow turbine blade

Project 6. Flow Analysis in the Turbine Blade.

Practice 11. Generation of 3D Sweep mesh for U-Bend Pipe.

Practice12. Post processing results for above studies.

Course Outline

CUON 2378 Research Methodology and IPR

Subject Name	Code	Type of course	T-P-Pr (Credit)
Research Methodology and IPR	CUON 2378	Theory+Project	**(2-0-2)** (04)

Objective

- To develop an appropriate framework for research studies
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research.
- To Demonstrate enhanced Scientific writing skills
- warn the common mistakes in the field of research methodology.

Course outcome

COs	Course Outcomes
CO1	Search, select and critically analyse research articles and papers
CO2	Formulate and evaluate research questions
CO3	Develop the ability to apply the methods while working on a research project work
CO4	Describe the appropriate statistical methods required for a particular research design
CO5	Choose the appropriate research design and develop appropriate research hypothesis for a research project in research methodology.

Module 1:Elementary Research Methodology

Research Concept, Objective, characteristics, Steps andSignificance of Research, Arbitrary and Scientific Research, Research approaches. Types of research: Historical, Descriptive, Analytical, Case Study, Quantitative vs. qualitative, Conceptual, Empirical Action Research, Research Methods vs Methodology. Research Problems: Selection and definition of the research problems,formulating a research problem,identifying variables and Constructing hypothesis;

Choosing a mentor, lab and research question; maintaining a lab notebook; Selection of problems - stages in the execution of research.

Module II: Academic Writing and Presentation

Technical writing skills - types of reports; layout of a formal report; standard of Journal (Impact Factor, Citation Index), Scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Module III: Scientific communication skills

Concept of effective communication- setting clear goals for communication; determining outcomes and results; barriers to effective communication; non-verbal communication- importance of body language, power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search.

Module IV: Introduction to IPR

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications. IP as a factor in R&D; IPs of relevance to biochemistry and few case studies; plant variety protection.

Module V: Types of Patents

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; filing of a patent application; role of a Country Patent Office; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of different regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications.

PROJECTS

1. Write a review article and submit to a journal.
2. Write a book chapter/ book for publishing.
3. Write an original article for a journal.

Books:

1. Geoffrey Marczyk, David DeMatteo, David Festinger (2005) ***Essentials of Research Design and Methodology***, John Wiley & Sons, Inc.
2. Carol Ellison (2010) ***McGraw-Hill's ConcisevGuide to WritingvResearch Papers***, McGraw-Hill
3. Kothari CR (2016) ***Research Methodology: Methods and Techniques***, New Age Pvt Ltd

4. Ganbawale RM, (2017) ***Bioststistics and Research Methodology***, New Central Book Agency
5. Sinha, S.C. and Dhiman, A.K., (2002). ***Research Methodology***, Ess Ess Publications. 2 volumes.
6. Trochim, W.M.K., (2005). ***Research Methods: the concise knowledge base***, Atomic Dog Publishing. 270p.
7. Wadehra, B.L. (2000). ***Law relating to patents, trademarks, copyright designs and geographical indications***. Universal Law Publishing.

Neuman, W.L. (2008). ***Social research methods: Qualitative and quantitative approaches.*** Pearson Education

Course outline

CUON1530 ADVANCED DIFFERENTIAL EQUATIONS

Subject Name	Code	Type of course	T-P-Pj	Prerequisite
ADVANCED DIFFERENTIAL EQUATIONS	**CUON1530**	**Theory+Practice+ Project**	**2-1-1**	

Objective

- Working with systems of ordinary differential equations and non-linearordinary differential equations is alsostressed.
- Developing and understanding and appreciation of the qualitative behaviour of the solution
- To introduce wave equations, Laplace equations, Heat equations, Diffusionequations.

Course outcome:

COs	Course outcomes
CO1	• Solve wave equation and understand significance of transverse waves.
CO2	• Identify classes of non-linear ordinary differentiale quations.
CO3	• Apply an appropriate method for the solution of non-linear ordinary differential equations.
CO4	• Competence in solving applied problems which are linear and nonlinear form, Solve Laplace equation, Diffusion equation, heat equation.
CO5	• Demonstrate the ability to succeed in national and international competitive exams like NET, GATE

Course outline

Module I:

Introduction to Ordinary Differential Equations and Partial Differential Equations, First Order Non- linear Ordinary differential equations such as Equations solvable for x, Equations solvable for y, Equations solvable forp.

Practice- 1: Solve Ordinary Differential Equations in Python

Practice-2: Solve Partial differential Equations by python

Module II

Partial differential equation of second order with variable coefficients- Monge's method and its properties.

Project 1: Monge's Method of Solution of Non-linear Partial Differential Equations of Order Two

Module III

Classification of linear partial differential equation of second order, Cauchy's problem, Method of separation of variables.

Module IV

Solution of one- dimensional Laplace equation by method of separation of variables and Fourier series

Project 2 : Solution of Laplace's Equation for a Disk

Module V

Solution of one- dimensional Wave equation by method of separation of variables and Fourier series

Project 3: D' Alembert's solution of the wave equation

Practice 3: Solution of wave equation associated condition

$u(x,0)=\varphi(x), u_t(x,0)=\psi(x), u(0,t)=0, x\epsilon(0,\infty), t>0$

Practice 4: Solution of wave equation associated condition

$u(x,0)=\varphi(x), u(0,t)=a, x\epsilon(0,\infty), t\geq 0$

Module VI

Solution of one- dimensional Diffusion equation by method of separation of variables and Fourier series

Project 4: Solution of Diffusion equation in n-dimensional

Practice 5: Solution of one-dimensional diffusion equation by using boundary conditions $u(x,0)=\varphi(x), u(0,t)=a, x\epsilon(0,\infty), t\geq 0$

Practice 6: Solution of one-dimensional diffusion equation

$u(x,0)=\varphi(x), u(0,t)=a, u(1,t)=b, 0<x0$

Module VII

Solution of one- dimensional Heat equation by method of separation of variables and Fourier series

Project 5: Two dimensional Heat equations- Polar form

Project 6: Temperature distribution in Rectangular plate

Text Books

1. Differential Equations and Their Applications, by Martin Braun, Springer, 4e, ISBN 9781111827052(1993).
2. S. L. Ross: Differential Equations, Blaisdell Publishing Company, Londan,1964.

Reference books:

1. S.J. Farlow: An Introduction to Ordinary Differential Equations,PHI
2. M.D. Raisinghania: Ordinary and Partial Differential Equations, S. Chand &Co.
3. V. Sundarapandian: Ordinary and Partial Differential Equations,McGraw-Hill

Developedby:(Facultyname), *Saubhagyalaxmi Singh*

Developed on (Month and Year): JUNE2020

Course outline

CUON-1531 GRAPH THEORY

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
GRAPH THEORY	**CUON-1531**	**Theory & Practice**	**3-1-0**	**Nil**

Objective:

- To introduce the students to graphs, their properties and their applications as models ofnetworks.
- To represent almost any physical situation involving discrete objects and a relationship amongthem.
- To introduce the students to generating functions and theirapplications.

Course outcome:

COs	Course outcomes
CO1	• Know the basic definitions and concepts of graph theory and Write in a coherent and technically accurate manner.
CO2	• Learn about how to develop graph theoretical algorithm and Know about many different coloring problems forgraphs.
CO3	• To demonstrate to the students that many problems-theoretical or real-life, can be analyzed and solved by using graphs.
CO4	• To developed the skill of translating problems to graph-theoretic problems and translating the solutions to the real-life problems.
CO5	• Apply abstract concepts of graph theory in modeling and solving non-trivial problems in different field of study

Course Outline

Module-I

Introduction to Graphs and Definition of graphs;Basic terminologies and types of graphs;Degree of a vertex,Isolated and Pendent vertices;Sub graphs and graph Isomorphism.

Practice 1: Determine if two graphs are isomorphic and identify the isomorphism

Module-II

Directed Graphs and Types of Digraphs;Out-degree, In-degree, Connectivity and Orientation;Digraphs and Binary relations , Directed paths and contentedness;Euler Digraphs, De-Brujin sequences;Tournaments.

Practice 2: Ways to Represent Graphs using Python

Module-III

Basic concepts of Planar Graphs; Kuratowski's Two graphs ;Representation of Planar Graphs; Detection of planarity ;Euler's formula for planargraphs;

Practice 3: A look in to Planar Graphs and Euler's Relationship

Module-IV

Distance, cut-vertices, cut-edges, blocks;weighted graphs, connectivity;Dijkstra's shortest path algorithm;Floyd-War shall Shortest path algorithm;

Module-V

Proper Coloring of graphs;Chromatic numbers of a graph;Chromatic polynomial;Chromatic Partitioning;Four Colour theorem.

Practice 4: Finding **C**hromatic number using python-networks.

Module-VI

Definition and properties of trees;Rooted and Binary trees; Counting trees, Spanning trees;

Practice 5: Applications of graphs with Euler and Hamiltonian path and circuits(Chinese postman Problem)

Module-VII

Minimum spanning trees;Fundamental Circuit;Cut set and Separability;

Practice 6: Application of Minimum spanning tree in a Net work model

Text Book:

1. Deo, N., "Graph Theory with Applications to Engineering and Computer Science", Prentice Hall India 2004

Chapters: 1(1.1,1.2,1.3,1.4,1.5) ,2 (2.1,2.2,2.4,2.4,2.6,2.9), 3 (3.1,3.2,3.5,3.7,3.8,3.9,3.10), 4 (4.1,4.4,4.5), 5(5.2,5.3,5.4,5.5), 7(7.1,7.2), 8 (8.1,8.2,8.3,8.6), 9 (9.1,9.2,9.3,9.4, 9.5)

Reference Books:

1. West, D. B., "Introduction to Graph Theory ", Prentice Hall India (2nd Edition2009)

2. Aldous, J. M., Wilson, R. J. and Best S., "Graphs and Applications: AnIntroductory Approach",Springer2003.
3. Deistel, R., "Graph Theory", Springer (4th Edition)2010.
4. Chartrand, G. and Zhang, P., "Introduction to Graph Theory", Tata McGrawHill2007.
5. Bondy, J. A. and Murty, U. S. R., "Graph Theory", Springer2011

CUON1532 OPTIMIZATION TECHNIQUES

Subject Name	Code	Type of Course	T-P-Pj (Credit)	Prerequisite
OPTIMIZATION TECHNIQUES	**CUON1532**	**T + P**	**3-1-0**	**Nil**

Course Objective

- To introduce a brief understanding about Non Linear ProgrammingProblems.
- To cater the characteristics of Non Linear Programming Problems andits Applications.
- To demonstration of the utilization of Non Linear Programming Problems in industry andbusiness.
- To apply the evolutionary optimization techniques in machine learningprediction model
- To solve the case study related to strategicmanagement

Course outcome:

Cos	Course outcomes
CO1	• Formulate the necessary and sufficient optimality conditions for Nonlinear programming and demonstrate the geometrical interpretation of theseconditions.
CO2	• Use Evolutionary optimization techniques to optimize the forecasting modelsin machinelearning.

CO3	• Use the optimization techniques learned in this course to formulate newapplications as optimal decision problems and seek appropriate solutionsalgorithms.
CO4	• Use of gradient method to solve applied engineering and fluid dynamic and Nano fluid problems.
CO5	• Use of game theory to make decision in critical business problem

Course Outline

CUON1532 Optimization Techniques (3-1-0)

Module-I (5 Hours)

Non Linear Constrained Optimization Problem: Constrained optimization using Lagrange Method, Lagrange Multiplier Equality Constraints, Constrained optimization using Kuhn Tucker Method, Kuhn Tucker inequality Constraints.

Practice-1: **(2 Hours)**
Solving minimization constrained optimization problem using python

Practice-2: **(2 Hours)**
Solving maximization constrained optimization problem using python

Module-II (5 Hours)
Direct Search Method for Unconstrained Optimization Problem: Univariate Search Method, Golden Section Search Method and Application of Golden Section Search Method.

Practice-3: **(2 Hours)**
Solving nonlinear system of equations using Python

Module-III (4 Hours)
Gradient Method for Unconstrained Optimization Problem: Gradient Descent Method, Algorithm for Gradient Descent Method, Steepest Descent Gradient Method.

Practice-4: **(2 Hours)**
Implementing Gradient Descent algorithm in Python

Practice-5: **(2 Hours)**
Linear Regression using Gradient Descent in Python

Module-IV (4 Hours)
Sequencing Models: Problems with n' Jobs through Two Machines, Problems with 'n' Jobs through Three Machines, Problems with Two Jobs through 'm' Machines.

Module-V (4 Hours)
Particle Swarm Optimization: Particle Swarm Optimization Theory, Particle Swarm Optimization Algorithm, Application of Particle Swarm Optimization,

Practice-6 & 7: **(2+2 Hours)**

Implementing the Particle Swarm Optimization (PSO) Algorithm in Python

Module-VI (4 Hours)

Game with Pure Strategy: Game and Strategy, Maximin-Minimax principle, Two person zero-sum game with Saddle Point, Solving matching coin problem using game theory.

Module-VII (4 Hours)

Game with Mixed Strategy: Mixed Strategy Game, Game without Saddle Point, Graphical Method to Solve Mixed Strategy Game, Dominance Principle to Solve Mixed Strategy Game.

Text Books:

Kanti Swarup, P.K. Gupta and Man Mohan-Operations Research, S. Chand and Co. Pvt.Ltd.

Engineering Optimization Theory and Practice by Singiresu S. Rao, JOHN WILEY & SONS, INC., Fourth Edition

Reference Book:

Mathematical Programming by N. S. Kambo, East West Press.

Course Outline

CUON1533 ADVANCED STATISTICAL METHODS

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUON1533	ADVANCED STATISTICAL METHODS	2-1-1	NIL

Objective

- Ability to summarize and present data numerically andvisually.
- Knowledge of which statistical methods to use in whichsituations
- Ability to think critically about data-based claims and quantitativearguments.
- Ability to learn new statistical analysis techniques on yourown.

Course outcome

COs	Course outcomes
CO1	• Apply statistical methods and hypothesis testing to businessproblems
CO2	• Learn the details and complexities of Analysis of Variance(ANOVA)
CO4	• Understand Chi SquaredTests and Understand different type of data.
CO5	• Learn some of the details and complexities of multiple regression (MR).

Course Content

Module I: (2 hrs+0 hrs+2hr)

Statistics: Population, Sample, Sampling, Estimators and Estimates, Maximum Likelihood , Confidence Intervals

Project-1

Application of Confidence intervals as a tool in decision making

Module II: (3 hrs+0hr+2hr)

Hypothesis Testing: Null and the alternative hypothesis, Rejection region and significance level, Chi-Square Test

Project-2

Hypothesis Testing in Quality Management

Module III: (4 hrs+4 hrs+0hr)

Regression: Multiple Regression and Logistic Regression

Practice-1

Multiple Regression Analysis in Python

Practice-2

Logistic Regression using Python

Module IV: (3 hrs+4 hrs+2hr)

Analysis of Variance (ANOVA): F- Distribution, One way ANOVA, Two Way ANOVA

Practice-3

One way ANOVA using Python

Practice-4

Two way ANOVA using Python

Project-3

The utility of multivariate statistical techniques in hydro geochemical studies

Module V: (3 hrs+2 hrs+2hr)

Covariance: (ANCOVA): Analysis of Covariance (ANCOVA), Bivariate Pearson Correlation, Alternative Correlation Coefficients

Practice-5

Python Analysis of covariance (ANCOVA)

Project-4

Application of Analysis of covariance (ANCOVA) in psychological research

Module VI: (3 hrs+0hr+2hr)

Multivariate analysis of variance (MANOVA): One-way MANOVA, Two-way MANOVA

Project-5

Comparison of MANOVA to ANOVA Using an Example

Module VII: (3 hrs+2 hrs+2hr)

Time Series Analysis: Introducing Time Series Analysis, Components of Time Series Analysis, Multivariate Time Series Analysis

Practice-6

Time Series Analysis using Python

Project-6

A Report on Applications of Time Series Analysis in Census Analysis

Text Books:

1. Statistical Methods By S.P. Gupta (31st Edition) ; Publisher: Sultan Chand &Sons

2. Mathematical Statistics by S.C. Gupta & V.K. Kapur (10th Edition); Publisher: Sultan Chand & Sons.

Reference Books:

Understanding And Using Advanced Statistics by Jeremy Foster Emma Barkus Christian Yavorsky, SAGE Publications

Course outline Prepared by: Dr.Banitamani Mallik **Date**: 18-06-2020

Course outline

CUON1534 APPLIED NUMBER THEORY

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
APPLIED NUMBER THEORY	CUON1534	Theory	3-1-0	Nil

Objective

- To analyze, evaluate, or solve problems with in given a set of circumstances ordata.
- To understand and utilize mathematical functions and empirical principlesand processes.
- Enhance and reinforce the student's understanding of concepts through the useof technology whenappropriate

Course outcome:

COs	Course outcomes
CO1	• Demonstrate knowledge and understanding of topics including applications.
CO2	• Investigation of ciphering code in cryptography.
CO3	• Learn methods and techniques used in number theory.
CO4	• Developing Problem Solving Technique
CO5	• Use mathematical induction and other types of proof writing techniques and programming to compute number theoretic problems.

Course Outline

CUON 1534 APPLIED NUMBER THEORY (3-1-0)

MODULE – I (4hr+2hr+0hr)

Divisibility, Representations of Integers,Computer Operations with Integers,Prime Numbers

Practice-1: Write a program to decide whether an integer is prime using trial division of the integer by all primes not exceeding its square root.

MODULE – II (6hr+4hr+0hr)

Greatest common divisor,EuclideanAlgorithm,Modified Euclidean Algorithm, Prime factorization,Factorization of Integers

Practice-2: Write a program to find the greatest common divisor of two integers using the Euclidean algorithm.

Practice-3:Find the prime factorization of a positive integer.

MODULE – III (5hr+2hr+0hr)

Congruence's, Properties of Congruence's,System linear Congruence's

Chinese Remainder Theorem.

Practice -4: Write a program to solves systems of linear congruence

MODULE – IV (5hr+0hr+0hr)

Wilson's Theorem,Fermat's Little Theorem,Pseudo prime, Carmichael number

MODULE – V (4hr+2hr+0hr)

Euler's Theorem, Euler Phi-function, Perfect Numbers, Mersenne Primes

Practice -5: Write programs to find values of the Euler phi-function

MODULE – VI (3hr+2hr+0hr)

Character Ciphers, Block Ciphers, Exponentiation ciphers, Public-Key Cryptography (RSA Cryptosystem).

Practice-6: Write a program for RSA crypto system/Algorithm

MODULE – VII (3hr+0hr+0hr)

Knapsack ciphers, Some applications to computer science.

BOOK PRESCRIBED

1. Elementary Number Theory and lts Applications by Kenneth H. Rosen, ADDISON-WESLEY PUBLISHING COMPANY ISBN 0-201-06561c chapter- 1(1.2-1.5), 2(2.1-2.4),3,5,6(6.1-6.3),7

BOOKS FOR REFERENCE

1. Elementary Number Theory by David M. Burton, fifth edition, McGraw-Hill Publication, ISBN-0-07-232569-0
2. A Course in Number Theoretic Cryptography by Neal Koblitz, Springer Verlag,GTM

Course outline

CUON1535 ADVANCED COMPLEX ANALYSIS

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
ADVANCED COMPLEX ANALYSIS	**CUON1535**	**Theory**	**3-0-1**	**Nil**

Objective

- To understand the applications of Residue for evaluation of definite and improper integrals occurring in Real analysis and Applied mathematics.
- To know about special functions like Riemann zeta function which plays a pivotal role in analytic number theory and has applications in physics, probability theory, and appliedstatistics.

Course outcome:

COs	Course outcomes
CO1	• Get a deep understanding of the fundamental concepts of Residues, Laurent series, Harmonic and Periodicfunctions.
CO2	• Evaluate definite and improper real integrals applying the Cauchy's ResidueTheorem.
CO3	• Evaluation of different types of real definite integrals using Residue theorem.
CO4	• Knowing about Harmonic functions, conjugate differential, The Mean-Value Property, Poisson's formula.
CO5	• Finding the Taylor series and Maclaurin series for an analytic function in a domain

Course Outline

CUON1535 Advanced Complex Analysis (3-0-1)

MODULE – I (3hr+0hr+0hr)

Index of a point with respect to a closed curve, Simply connected region, General statement

of Cauchy's theorem.

MODULE – II (4hr+0hr+2hr)

Residue, process for finding out the residues, Residue theorem,the Argument Principle.

PROJECT 1: Study on Residues and their applications.

MODULE – III (5hr+0hr+2hr)

Definite Integrals: Evaluation of definite integrals (Types -1, 2, 3, 4, 5).

PROJECT 2: Evaluation of different types of real definite integrals using Residue theorem.

MODULE – IV (4hr+0hr+2hr)

Harmonic functions, conjugate differential, The Mean-Value Property, Poisson's formula.

PROJECT 3: A study on Harmonic functions.

MODULE – V (6hr+0hr+2hr)

Taylor Series, Taylor's theorem, Laurent series, Laurent's theorem, infinite products, theorems on infinite products.

PROJECT 4: A study on Laurent series expansion of different types of meromerphic functions.

MODULE – VI (3hr+0hr+2hr)

Entire functions: Jensen's formula, Riemann Zeta function, theorem on Riemann Zeta function.

PROJECT 5: A study on Riemann Zeta function and it's properties.

MODULE – VII (6hr+0hr+2hr)

Simply periodic function, Module, Discrete module, Unimodular transformation, Canonical basis, theorem on Canonical basis.

PROJECT 6: A study on discrete modules.

BOOK PRESCRIBED

1 L. V. Ahlfors, “Complex Analysis”, McGraw-Hill, Inc.

Chapters: 4 (2.1, 4.2 to 4.5, 5.1 to 5.3, 6.1 to 6.3), 5 (1.2, 1.3, 2.2, 3.1, 4.1), 7 (1.1, 2.1, 2.2,2.3)

Course outline

CUON1536 TOPOLOGY

Subject Name	Code	Type of course	T-P-P	Prerequisite
TOPOLOGY	**CUON1536**	**Theory & Project**	**3-0-1**	**NIL**

Objective

- To introduce the student to elementary properties of topological spaces andstructures defined onthem
- To introduce the student to maps between topologicalspaces
- To develop the student's ability to handle abstract ideas of Mathematics and Mathematical proofs

Course outcome:

Cos	Course outcomes
CO1	Understanding elementary properties of topological spaces and structures defined on them
CO2	Construct maps between topologicalspaces ability to handle abstract ideas of Mathematics and Mathematicalproofs
CO3	• Demonstrate a knowledge and understanding of Urysohn's metrization theorem**,** Urysohn's Lemma those leads future contemporary research on the relevant field.
CO4	Demonstrate an understanding of the concepts of metric spaces andtopological spaces, and their role inmathematics. Demonstrate familiarity with a range of examples of thesestructures.
CO5	Prove basic results about completeness, compactness, connectedness andconvergence within thesestructures.

Course outline

Module I

Introduction oftopologicalspace**,** Open sets and limit points, Closed sets and closure, Bases and relativetopologies

Project 1: Applications of Topology to the Analysis of 1-DimensionalObjects

Project 2: Topologies sequentially equivalent to Kuratowski Painlev´econvergence

Module II

Connected sets and components,compact and Countable compact spaces **,** continuous functions, Homeomorphisoms

Project 3: Sober topological space

Module III

To-and T1-spaces and sequence, Separation axioms

Module IV

Axioms of count ability, Regular and normal spaces, Completely regular spaces

Project 4: Upper Topology

Module V

Urysohn's metrization theorem **,** Urysohn's Lemma, Metrization**,** Tietze extension theorem

Project 5: Scott topology

Project 6: Scott continuity

Module VI

Finite products, product

invariant properties, product

topology

Module VII

Metric topology, Metric products, Dense set

Text Books

1. W.J. Pervin, Foundations of General Topology, Academic Press. Chapters: 3 (3.1, 3.2 and 3.4), 4(4.1 to 4.4), 5 (5.1 to 5.3, 5.5 and 5.6), 8 (8.1 to 8.4), 10 (10.1only).
2. J. R. Munkres; Topology – A First Course, Prentice Hall of India,1996.

Reference Book

1. K. D. Joshi, Introduction to General Topology, Wiley Eastern Ltd.,1983.
2. http://mat.uab.cat/ret/sites/default/files/material/otras_contribuciones/ProceedingsWIAT10.pdf

Developed by:(Faculty name), Saubhagyalaxmi Singh

Course outline

CUON 1537 DIFFERENTIAL GEOMETRY

Subject Name	Code	Type of course	T-P-Pj	Prerequisite
DIFFERENTIAL GEOMETRY	**CUON 1537**	**Theory & Project**	**3-0-1**	**NIL**

Objective

- This course unit aims to introduce the basic ideas and techniques of Differential Geometry for use in many othercourses.
- To study about different geometrical skills for figure and their representation in mathematical equations
- To study about notations and operations ofTensor.

Course outcome:

COs	Course outcomes
CO1	• Write equation of normal ,binormal and tangent to acurve.
CO2	• Able to understand tonsorial expressions.
CO3	• Judge the shape of geometrical figure from equation.
CO4	• Solving differential geometrical problems.
CO5	• Producing different shaped object using mathematical equation.

Course outline

Module-I

Introduction to Differential Geometry,Osculating plane and Rectifying Plane

Project 1:.finding the direction of tangent , normal and binormal at any point of curve

Module-II

Curvatures of a curve at a point,Torsion of a curve at a point, Expression of Curvature and Torsion in terms of arc length parameter, Expression of Curvature and Torsion in terms of arbitrary parameter

Project 2: Compute the Curvature of an ellipse.

Module-III

Spherical Indicatrix, Evolutes , Involutes

Project 3: Determine the evolutes of the given curve.

Module-IV

Betrand Curve,Osculating Spheres , Osculating circles.

Project-4 : Show that the tangent to the locus of osculating sphere passes through the centre of the Oscilating Circle.

Module-V

Surface: Tangent planes and Normals,The two fundamental forms

Project 5: Find the normal to a given surface

Module-VI

Tensor : Definitions and explanations,Vector Space,Free systems, Basis and Dimension, Suffix Conventions,Transformation law for change of Basis Vectors and Components ,Dual Spaces

Module-VII

Transformation law for change of Basis in dual Space, Isomorphism, Tensor Product of Vector Spaces, Real Valued Bilinear Functions, Special Tensors

Project-6: Show that the velocity of a fluid at any point is component of a contravariant vector

BOOK PRESCRIBED

1. A text book of vector calculus-Shanti Narayana and J.N.Kapoor
   Chapters: II andIII
2. An Introduction to Differential Geometry by T.G. Willmore-Oxford University Press (1983) Chapters:V

BOOK FOR REFERENCE

1. Differential Geometry-P.P.Gupta,G.S.Malik,S.K.Pundir
2. Tensor Analysis- Edward Nelson(Princeton University Press & University of Tokyo Press),1967
3. Introduction to Tensor Analysis and the Calculus of Moving Surfaces-Pavel Grinfeld,Springer

Developed by:(Faculty name) : Dr T.N.Samantara

Course outline

CUON1538 ADVANCED ALGEBRA

Subject Name	Code	Type of course	T-P-P(Credit)	Prerequisite
ADVANCED ALGEBRA	**CUON1538**	**Theory**	**3-0-1**	**Nil**

Objective

- A major objective is to introduce students to the language and precision of modern algebra. This means that the course will be proof-based, in the sense that students will be expected to understand, construct, and writeproofs.
- A challenge for all students of mathematics is to balance the understanding with the communication. There is a tendency to think you are finished once you see why a mathematical statement is true orfalse.
- In fact you are just half-way there because constructing a legitimate proof involves different skills and expertise than the discovery part of the process. In this course both angles of problem-solving will bestressed.

Course outcome:

COs	Course outcomes
CO1	• Effectively write abstract mathematical proofs in a clear and logicalmanner.
CO2	• Locate and use theorems to solve problems in number theory and theory of polynomials over afield.
CO3	• Demonstrate ability to think critically by interpreting theorems and relating results to problems in other mathematicaldisciplines.
CO4	• Demonstrate ability to think critically by recognizing patterns and principles of algebra and relating them to the numbersystem.
CO5	• Work effectively with others to discuss homework problems put on theboard.

Course Outline

CUON1538 Advanced Algebra (3-0-1)

MODULE – I (6hr+0hr+2hr)

Group Theory:

Another Counting Principle, Sylow's Theorems.

Project 1 : A Notes on the Proof of the Sylow Theorem

MODULE – II (6hr+0hr+2hr)

Ring Theory:

Introduction to Ring, Some special classes of ring, Ring homomorphisms.

Project 2: A study on ring theory and it's property

MODULE – III(3hr+0hr+2hr)

More Ideals and Quotient Rings, The Field of Quotients of an Integral Domain.

Project 3: The Quotient Field of an Intersection of Integral Domains

MODULE – IV(4hr+0hr+2hr)

Euclidean Rings, A Particular Euclidean Ring, Polynomial Rings.

Project 4: On the Existence of a Euclidean Algorithm in Number Rings with Infinitely Many Units

MODULE – V (4hr+0hr+0hr)

Polynomial Rings over the Rational Field, Polynomial Rings over Commutative Rings.

MODULE – VI (3hr+0hr+2hr)

Fields:

Extension Fields, Roots of polynomials

Project 5: A study on Structure of a Finite Field

MODULE – VII (4hr+0hr+2hr)

Vector Spaces:

Elementary Basic Concepts of Vector Space, Linear Independence and Basis, Dual Spaces, Inner Product Spaces

Project 6: Notes on dual spaces

BOOK PRESCRIBED

Topics in Algebra – I. N. Herstein (John Wiley and Sons or Vikas Publication), 2nd Edition

Chapters: 2 (2.11 to 2.12), 3 (3.1 to 3.11), 4 (4.1 to 4.4), 5(5.1 and 5.3)

BOOKS FOR REFERENCE

1. S.Singh and Q. Zameeruddin, Modern Algebra, Vikas Publishing House,1990
2. P.B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, Cambridge University Press,1995.

Domain Track Title: Computational Fluid Dynamics

Track Total Credits-20 (2+10+8)

Course Division(List all divisions):

1. CFON2180 Introduction to CFD (2+0+1)

2. CFON2181 Grid Generation (0+2+0)

3. CFON2182 Flow Solver Techniques-Simulia (0+3+1)

4. CFON2183 Simulation and Validation (0+5+0)

5. CFON2184 Industry Specific Project (0+0+6)

Domain Track Objectives:

- To provide the knowledge of CFD in the Industrial Level.
- To apply CFD methods as a tool for design, analysis and engineering applications.

Domain Track Learning Outcomes:

- To impart knowledge about various computational methods for fluid flow and heat transfer problems so as to enable the students to write computer programs for solving elementary fluid dynamics/heat transfer problems.
- To execute the industry projects so as to produce Quality products to the Clients.

Domain Syllabus:

1. Introduction to CFD (2-0-1)

Module-1

Fluid, Properties of Fluid (Temperature, Vapour Pressure, Viscosity, Specific Gravity, Compressibility, Speed of Sound, Density, Energy, Specific Heat, Newtonian and Non-Newtonian Fluids

Module-2

Lagrangian and Eulerian Approaches, Classification of Fluid Flow (Inviscid vs. Viscous, Laminar vs. Turbulent, Incompressible vs. Compressible, Internal vs. External, Steady vs. Unsteady, Rotational vs. Irrotational, 1D, 2D and 3D Flows)

Project 1. Case studies in industrial pipe flows.

Module-3

Governing Equations of Flow Field (Conservation of Mass, Momentum (Navier-Stoke Equation) and Energy)- Differential Form, Integral Form.

Project 2. Case studies and generation of drag and lift for flow over bodies.

Module-4

Flow Features (Stagnation, Boundary Layer (Laminar to Transition to Turbulent), Flow Separation), Drag & Lift forces, Types of Boundary Conditions.

Project 3. Case studies in different types of aerofoil and its applications.

Module-5

Heat Transfer in Fluid (Conduction, Convection (Natural, Forced), Radiation), Non-dimensional Quantities, Grid Generation, Flow Similarity between Prototype and Model.

Project 4. Case studies for various non-dimensional quantities and its importance in CFD.

Module-6

CFD and its applications, Discretization methods for the CFD (FDM, FVM, FEM, Hybrid Methods).

Project 5. Case studies for the various applications of CFD and its significance.

Module-7

Turbulence Modelling, CFD Solution Tool Chain

Project 6. Case studies for the different turbulence modelling in CFD.

2. Grid Generation (0-2-0)

2.1 Introduction to Meshes- CFD Meshing Basics

2.2 Different Element Shapes- Creating, Managing & Updating Meshes

2.3 CFD Meshing- 2D Mesh, 3D Mesh, Mapped Face Meshing,

Practice 1. 2D mapped Mesh for rectangular pipe

Practice2. 2D mapped Meshing for Aerofoil.

2.4 Structured Meshing, Un-Structured Mesh, Sweep 3D Mesh

Practice 3. 3D structure mesh of Circular Cylinder

Practice 4. 3D unstructured mesh with prims layers for Aerofoil

Practice 5. 3D coarse/ medium/ fine sweep mesh for pipe

Practice 6.3D coarse/ medium/ fine unstructured Octree Tetrahedron mesh for Aerofoil.

Practice 7. 3D hex- dominant mesh for rectangular Duct.

2.5 Visualization the Mesh- Visualization Management, Mesh Visualization Options, Section, Clipping Box, Mesh colour, Element shrink

2.6 Reviewing the Mesh- Quality Analysis, free Edges, Interfaces, Duplicate Checker, Isolate Node Checker

Practice 8. 3D hex-dominant with surface mesh, Boundary prim mesh for DS car.

Practice 9. 3D Tetrahedron filler mesh Narrowing pipe.

Practice 10. 3D Tetrahedron, surface, for Electronics Module.

Practice 11. 3D Sweep mesh for circular cylinder.

Practice 12. 3D mesh generation for Subsonic Converging-diverging Nozzel.

Practice 13. 3D Sweep mesh generation for U-Bend pipe.

Practice 14. 3D mesh generation of Dimple Ball.

Practice 15. 3D mesh generation of a wedge body.

3. Flow Solver Techniques-SIMULIA (0-2-1)

3.1 Overview-Fluid Dynamics Engineer Essentials

- Connecting to the platform, Assigning roles and Apps, Platform Interface, Importing 3D XML file, Simulation Conventions in the 3DExperience Platform

Practice 1. Getting Started with the 3DExperience Platform.

3.2 Import an assembly

- Explore the imported assembly, Renamed the assembly, Search for parts/assemblies in the database, open parts/ assemblies found through search, duplicate, delete and save entities, Import a 3D XML file containing fluid materials, Create and save a new material.

3.3 Fluid Dynamics Engineer Role Overview

- Exploring Fluid Dynamics Engineer Role Apps, CFD simulations work flow, Model preparations, Material definitions, Meshing, CFD analysis, Analysis convergence, co-simulation Analysis, Post processing results, CFD solver validations.

Practice 2. CFD analysis of steady state internal Laminar Pipe flow.

Project 1. Analysis of pipe flow at Re= 500.

3.4 Getting Started with CFD Simulations

- Fluid Model Creation, Fluid Scenario Creation App Interface, Model setup, applying meshing, Scenario Setup, Results visualizations, Reviewing Simulation Features,

Practice 3. CFD analysis Steady-state external flow over an Airfoil.

Project 2. Analysis of 2D cylinder in a rectangular domain with varying radius and height.

3.5 Geometry for CFD Simulations

- Geometry Preparation- Check and Repair, Defeature Idealize, Create, Healing, Join, Local Join, surface connection Checker, Face checker, Mid surface

Practice 4. Modeling of Air intake system.

Practice 5. Extracting Fluid volume for Engine Manifold.

3.6 Material and Section Properties of Fluid

- Understanding materials, working with materials, Creating a new Material, Applying a Material, Adding New Domains, Editing a Material Domain, Simulation Domain, Material Behaviors in a Simulation Domain, Section Properties, working with Imported Meshes

3.7 Defining Physics of Fluid

- Analysis Procedures- Enabling Temperature, Compressible, Coupled vs Segregated solver, Gravity effects.
- Turbulence Modelling- SST k-w, Realizable k-e, Spalart-Almaras, Radiation Modeling, Steady-state Analysis, Transient Analysis- Courant-Freidrichs-Levy (CFL) condition, Grid Independence Study, Bad cell Treatment

Practice 6. Grid Independence study for above cases (pipe / airfoil) using different solver schemes.

Project 3. Analysis of flow an over a circular cylinder at $Re=10^7$.

Practice 7. Conjugate Heat Transfer (CHT) Analysis of an Electronics Module.

Project 4. Analysis of temperature rise through cross flow heat exchanger.

3.8 Boundary and Initial Conditions

- Boundary Conditions, wall boundary conditions, Thermal wall boundary, Initial Conditions, Initializing Compressible flows, Turbulence Specifications at Boundaries, Surface- to – surface Radiation specification at Boundaries, Time- dependent Boundary Conditions, Spatially- Varying Boundary conditions, User defined Boundary conditions.

3.9 Turbulence Modeling&Modeling Techniques.

Practice 8. Aerodynamics analysis of DS car.

Practice 9. Unsteady Flow across a Circular Cylinder.

Practice 10. Transonic Flow over an Airfoil.

Project 5. Analysis and estimation of Drag lift coefficients flat plate at Re=10,000.

3.10 Solution Convergence

Practice 11. Cavitating Flow through a Narrowing Pipe.

Project 6. Analysis of compressible flow nozzle with atmospheric pressure at the nozzle exit.

3.11 Post-processing Results.

Practice 12. Creating Post processing reports for all the above cases.

4. Simulation and Validation (0-4-0)

4.1 Fluid flow in the rear duct of an automotive HVAC system.

4.2 CFD Analysis of an Air intake system.

4.3 CFD Steady-state External flow over a Drone in cruise.

4.4 DE featuring of a Lens Component.

4.5 CFD analysis for Conjugate Heat Transfer in a fan –cooled CPU Board.

4.6 CFD analysis Energy computations in a Contact Analysis.

4.7 Thermo-mechanical Analysis of a Laser Powder Bed Fusion Build.

4.8 CFD analysis in Turbulent pipe flow.

4.9 CFD Supersonic flow analysis for 3D cone.

4.10 CFD analysis over a Ahmed body.

5. Industry Specific Projects (0-0-6)

(Selected Projects will be carried out)

5.1 CFD Analysis of economizer in a tangential fired boiler.

5.2 Analysis and comparison of vertical tube with smooth tube.

5.3 A CFD-based analysis of the 14-bis aircraft aerodynamics and stability.

5.4 CFD analysis of gas flow behaviour in economizer duct.

5.5 Combined aerodynamic and structural optimization of a high-speed civil transport wing.

5.6 Fluid flow and temperature distribution in radiators used in automobiles.

5.7 Analysis of Cyclone dust collector air flow.

5.8 CFD analysis of shell and tube heat exchanger with fins for waste heat recovery application.

5.9 A theoretical analysis and CFD simulation on the on the ceramic monolith heat exchanger.

5.10 Analysis of water flow for Laminar & Turbulent Flow in Conventional Water Tap.

5.11 CFD Investigation of Airflow on a SANTRO Zing Car by using Fluent.

5.12 CFD analysis of rocket nozzle.

5.13 CFD analysis of supersonic exhaust in a scramjet engine.

5.14 Aerodynamic Design for Bus/Car Vehicle.

5.15 CFD analysis of exhaust manifold.

5.16 CFD analysis of centrifugal fan.

5.17 Analysis of intake manifold in SI engines.

5.18 CFD modelling of the automobile catalytic converter.

5.19 CFD analysis of fluid flow and heat transfer in a single tube-fin arrangement of an automotive radiator.

5.20 Computational flow field analysis of a vertical axis wind turbine.

Data Science and Machine Learning

	Course Title	T-P-Pj (Credit)	Prerequisite
	Data Science and Machine Learning	2-9-15	NIL

Course Objectives

- Understand the scope, stages, applications, effects and challenges of ML.
- Understand the mathematical relationships within and across ML algorithms and the paradigms of supervised and unsupervised learning.
- Able to get jobs in AI/ML field

Course Outcomes

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on design and implementation of various machine learning algorithms in a range of real-world applications.	PO1 (3)
CO2	Able to analyze prediction and classification using different ML and deep learning methods	PO2(3)
CO3	Ability to solve the real world problems using ML solutions in their respective fields of study.	PO2(3)
CO4	Ability to design product	PO3 (2), PO5(2)
CO5	Able to do research for publishing articles/ file patents.	PO4 (3)

ML for Predictive Analysis (0+2+2)

https://careerfoundry.com/en/blog/data-analytics/regression-vs-classification/
Project/Task: (Choose two projects, Prediction and Classification)
Time Series Analysis
Health Care System

Concept Required:

3.1 Data pre-processing: -

- Accessing / collecting the datasets from different online repository.
- Missing values handling, noise reduction, finding Correlation between features, outlier elimination.
- Label Encoding / Encoding the categorical data
- Splitting the dataset
- Data Normalization

3.2 Learning Algorithms: -

- Supervised Learning Algorithms
- Unsupervised Learning Algorithms

3.3 Feature extraction and selection: -

- Principal Component Analysis (PCA)
- Linear Discriminant Analysis (LDA)
- Different Feature Selection Techniques / Algorithms

3.4 Model building: -

- Regression (Linear, Polynomial, multiple, logistic), Decision Tree, Random Forest.

- Artificial Neural Network (Feed Forward Neural Network, Gradient Descent, Back Propagation Neural Network).
- Convolutional Neural Network
- Other Pretrained Models

3.5 Performance measures: -

- Perdition: Root Mean Square Error (RMSE), Average Percentage Error (APE), Mean Average Percentage Error (MAPE).
- Classification: Confusion Matrix (TN, TP, FP, FN), Sensitivity, Specificity, Gmean, F-score, Overall Accuracy, (Receiver Operating Characteristic) ROC Curve. Area under Curve (AUC)

3.6 Reading and Writing Research Articles

ML for Image Analytics (0-2-2)

Project/Task: (Choose one among six Tasks)

Detection of optometry diseases using retinal fundus imaging.

1. Diabetic Retinopathy
2. Glaucoma
3. Cataract

Detection of various diseases using X-ray imaging.

1. Covid19

Leaf disease classification using RGB images.

1. Tomato leaf
2. Potato leaf

Concept Required:

Image Pre-processing:-

- Accessing individual pixels using matrix concept
- Image resize, grey scale conversion, Colour channel splitting
- Histogram equalisation (CLACH).

Image Feature Extraction: -

- Edge detection (Sobel, Canny), Morphological operations
- Image segmentation, Image Thresholding, Binary conversion
- Cluster based segmentation
- Feature extraction based on size, shape and colour
- Feature extraction using predefined functions: SIFT, SURF, STAR, ORB.
- Feature Extraction using convolutional neural network (CNN).

Creation of Feature Matrix by combining Extracted Features: -

- Matrix flattening, Horizontal stacking, Vertical stacking, padding.
- Splitting the feature matrix (training/testing) and labelling.

Classification algorithms: -

- Support vector machine (SVM)
- Different kernels of SVM (linear, polynomial, radial basis function).
- Gradient Boosting (GB)
- Multi-layer Perceptron (MLP), deep learning.

Mathematics for ML (2+1+0)

When Models Meet Data:-

- Data, Models, and Learning

- Empirical Risk Minimization
- Parameter Estimation
- Probabilistic Modeling and Inference
- Directed Graphical Models
- Model Selection

Linear Regression:-

- Problem Formulation
- Parameter Estimation
- Bayesian Linear Regression
- Maximum Likelihood as Orthogonal Projection

Dimensionality Reduction with Principal Component Analysis:-

- Problem Setting
- Maximum Variance Perspective
- Projection Perspective
- Eigenvector Computation and Low-Rank Approximations
- PCA in High Dimensions
- Key Steps of PCA in Practice
- Latent Variable Perspective

Density Estimation with Gaussian Mixture Models:-

- Gaussian Mixture Model
- Parameter Learning via Maximum Likelihood
- EM Algorithm
- Latent-Variable Perspective

Classification with Support Vector Machines:-

- Separating Hyperplanes
- Primal Support Vector Machine
- Dual Support Vector Machine
- Kernels
- Numerical Solution

Practice:

- Curve Fitting in Python.
- Exploratory Data Analysis in Python.
- Kernel Density Estimation in Python.
- Probability Distribution Function Plotting in Python.
- Cumulative Distribution Function Plotting in Python.
- Dimensionality Reduction and Feature Extraction in Python.

References:

1. Mathematics for Machine Learning by Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong.
2. https://youtube.com/playlist?list=PLLy_2iUCG87D1CXFxE-SxCFZUiJzQ3IvE

IoT Analytics (0+2+2)

Defining IoT Analytics and Challenges

IoT

Benefits of Deploying IoT

End to End IoT architecture
IoT challenges

IoT Protocols

1 Wireless Protocol

Connectivity Protocols (when Power is Limited)
Bluetooth Low Energy (BLE)
Zigbee
LoRaWAN
NFC

2 Connectivity Protocols (when Power is Not a problem)

Wifi

3 Data Communication Protocol

MQTT
Web-Socket
HTTP

2 Sensors

Types of Sensors based on communication-I2C, SPI
Types of Sensors based on Application

3 Overview of 32 -bit Controller

ESP8266
ESP32
Raspberry Pi

4 AWS IoT for Cloud

AWS IoT Core services
AWS IoT Analytics services
AWS DynamoDB Services

5 Thingspeak for IoT

Getting and posting Data to IoT Cloud using ESP devices
Posting Data to IoT Cloud using Raspberry Pi

6 ThingWorx for Industrial IoT

Building Dashboard on Thingworx platform
Binding the senor value to the dashboard

Text Book:

1. Minteer, Andrew. *Analytics for the Internet of Things (IoT)*. Packt Publishing Ltd, 2017.

Reference Books:

1. Geng, Hwaiyu, ed. *Internet of things and data analytics handbook*. John Wiley & Sons, 2017.

Digital video Processing (0+2+1)

UNIT 1:

Fundamentals of Video Processing: Digital Video Acquisition, Principles of Color Video, Video Camera, Video Display, **Analog Vs Digital Video**: Progressive Vs Interlaced scans, Signal, Bandwidth Characterization of a Digital Video Signal.

Practice:

- Read and play video files
- Extract frames from video files
- Combine frames to create a video file

UNIT 2:

Fourier Analysis of Digital Video Signals: Spatial and Temporal resolution, Fourier Analysis of Digital Video Signals, **Spatial-Temporal Sampling:** Temporal Frequency Response and Flicker Perception. Spatial Frequency Response, Spatiotemporal Frequency Response, Smooth Pursuit Eye Movement

Practice:

- Applying fourier transformation on video
- Time domain analysis
- Frequency domain Analysis

UNIT 3:

Digital Video Formats: Significance of Video Formatting, Data rate and bandwidth trade-off, **File Formats:** MP4, MOV, WMV, AVCHD, FLV, AVI, WebM, MKV

Digital Video Compression Standards: Digital Video Compression Metrics, Digital Video Storage Precisions, Significance of Video compression, **Video Compression Codec's:** Motion JPEG, JPEG 2000, H.264/MPEG-4 AVC, VP8, HEVC, H.265 High Efficiency Video Codec.

Practice:

- Conversion of video files from one format to another.
- Using Motion JPEG Codec
- Using MPEG-4 Codec
- Using H.265 Codec

UNIT 4:

Digital Video Editing Basics: Video Editing Types- Online, Offline, Linear, Non-linear, Assemble, Insert, Rough-cut, Video Shot Transition Effects: Cut, Fade, Wipe, Dissolve, B-roll, Video Shot Boundary Detection Methods: pixel differences, statistical differences, histogram comparisons, edge differences and motion vectors. Video Shot Detection Performance Metrics: ROC Curves, Recall, Precision, F-Measure

Practice:

- Video Shot Detection using pixel Difference
- Video Shot Detection using Histogram based methods
- Video Shot Detection using Edge based methods
- Video Shot Detection using Motion Vectors

Project List

1. Creating a VIDEO object detection system
2. Vehicle detection in Videos using OpenCV and Python
3. Detecting faces in live camera feed with identification of the person.

TEXT BOOK:

1. Rafael C Gonzalez and Richard E Woods, "Digital Image Processing'', Pearson Education, 3rd Edition, 2009.
2. Handbook of Image and Video processing - Al Bovik (Alan C Bovik), Academic Press,

REFERENCE BOOK:

1. Fundamentals of Digital Image Processing", Anil K. Jain, PHI, 1995.
2. "Digital Image Processing", William. K.Pratt, Wiley Interscience, 2nd Ed, 1991.

Project (0-0-4)

Internship (0-0-4)

(Domain Courses)
NET Domain

Sl.No	Code	Subject Name	Cerdit	Course Type (Th+Pr+Pj)
1	NTON2480	Functional Analysis	4	3-0-1
2	NTON2481	Integral Equation	4	3-0-1
3	NTON2482	Advanced Calculus	4	3-0-1
4	NTON2483	Operation Research	4	3-0-1
5	NTON2484	Descriptive statistics & Data analysis	4	3-0-1
		Total	20	

Course outline

NTON2480Functional Analysis

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
FUNCTIONAL ANALYSIS	**NTON2480**	**Theory+Project**	**3-0-1**	**Nil**

Objective

- To get sufficient knowledge about different analytical structures, concepts and Theorems.
- In much of analysis, the emphasis is not on finding explicit solutions to specific problems, but rather on determining which problems can be solved and what general properties solutions may share.

Course Outcome

COs	Course outcomes
CO1	• Learn fundamental concepts like linear space, linear map, and Continuous map.
CO2	• To have a focus on the terms like dimension, basis, compactness, normed space.
CO3	• Solving problems involving linearly independent and dependent set, basis.
CO4	• To have a focus on bounded linear maps, Lp spaces.
CO5	• To know about Sequence spaces, Lp space, Function spaces, Inner product spaces.

Course outline

NTON2480Functional Analysis

MODULE-I

Linear space, Hamel basis, Span of a linear space, Quotient space, Product space.

Project-1: A study on Linearspaces.

MODULE -II

Linear map, Range space, Zero space, Hyperspace, Linear maps on finite dimensional linear spaces.

Project-2: A study on Linear maps.

MODULE – III

Compactness, Some fundamental theorems regarding compactness.

Project-3: A study on Compactness.

MODULE – IV

Normed space, Euclidian norm, Sequence spaces, Lp space, Function spaces, Inner product spaces.

Project-4: A study on Normed spaces.

MODULE – V

Quotient norm, Riesz Lemma, Some theorems regarding normed spaces.

MODULE – VI

Continuity of linear maps, Complete space, Some fundamental theorems.

Project-5: A study on Continuous linear maps.

MODULE – VII

Bounded Linear maps, Some fundamental theorems,

Project-6: A study on Bounded Linear maps.

BOOK PRESCRIBED

Functional Analysis—B. V. Limayee (New Age— International Limited,Publishers, Second Edition)

Chapters: 2, 2.1, 2.2, 2.3, 2.4, 2.5, 3.5, 3.6, 3.7, 5, 5.1, 5.2, 5.3, 5.4, 6, 6.1, 6.2, 6.3, 6.6, 6.7, 6.8.

Course outline

NTON2481 INTEGRAL EQUATION

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
INTEGRAL EQUATION	**NTON2481**	**Theory+ Project**	**3-0-1**	**Nil**

Objective

- This course unit aims to identify different type of Integral equations
- To Solve different type of Boundary value problems of Integral Equations in nature
- To Convert differential equations into Integral equations

Course Outcome

COs	Course outcomes
CO1	Defining Integral equation and its types
CO2	Forming Integral equations from differential equations and vice versa
CO3	Solving Integral eqquations
CO4	Modeling the problems having integral equation.
CO5	Demonstrate the ability to succeed in national and international competitive exams like NET, GATE

Course outline

INTEGRAL EQUATION

MODULE– I

Introduction, Definitions of Integral Equation ,Linear, Non Linear Equations ,Fredholm Integral Equation, Volterra Integral Equation, Singular Integral Equation, Special Kinds of Kernels , Integral equations of Convolution type, Iterated Kernel sand Resolvent Kernel.

Project 1: Prepare a detail report of different kind of Integral Equations.

MODULE– II

Eigen values, Leibnitz's rule of differentiation under integral sign, Formula for converting multiple integral into single ordinary integral, Regularity conditions, Inner product of two functions, Definition and some simple examples of Solution of Integral Equations.

Project 2: Prepare a report on Leibnitz's rule of differentiation under integral sign and Formula for converting multiple integral into single ordinary integral.

MODULE– III

Conversion of Ordinary differential equations into integral equations.

Project 3: Prepare a report on advantages of Conversion of Ordinary differential equations into integral equations

MODULE– IV

Homogeneous Fredholm Integral Equations of the Second kind with Separable Kernels.

Project-4 : Prepare a report on advantages of Fredholm Integral Equations of the Second kind

MODULE– V

Fredholm Integral Equations of the Second kind with Separable Kernels

MODULE– VI

Method of Successive approximations: Concepts, Solution of Fredholm Integral Equation of the Second Kind by Successive Substitutions.

Project 5: Prepare a report on Solution of Fredholm Integral Equation of the Second Kind by Successive Substitutions.

MODULE– VII

Solution of Volterra Integral Equation of the Second Kind by Successive Substitutions.

Project-6: Prepare a report on Solution of Volterra Integral Equation of the Second Kind by Successive Substitutions

BOOK PRESCRIBED

1. Integral Equations and Boundary Value Problems by M.D. Raisinghania, S.Chand & Company pvt Ltd. Ch-1, Ch-2, Ch-3, Ch-4 Ch-5 (5.1-5.7)

BOOK FOR REFERENCE

1. Introduction to Integral Equations with Applications , A.J. Jerri, Wiley-Interscience Publication,1999
2. Linear Integral Equations, W.V Lovitt, , McGraw Hill, New York

Developed by:(Faculty name) : Dr T.N.Samantara

Course outline

NTON2482ADVANCED CALCULUS

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
ADVANCED CALCULUS	NTON2482	Theory+Practice+Project	3-0-1	Nil

Objective

- To study about Taylor'stheorem. It provides a framework for application of Taylor'stheorem in problems
- To construct an over view on Green, Gauss & Stokes Theorem

Course Outcome

COs	Course outcomes
CO1	• Understand the importance of linear functions in mathematics.
CO2	• Deals with the major problems of differential and integraltransforms.
CO3	• Recognize other important classes of functions (such as trigonometric and rational functions), and will be able to use calculus with thesefunctions.
CO4	• Deals with the major problems on Power Series, Improper integrals with parameters.
CO5	• Recognize other important classes of functions such as Gamma Function. Beta Function

Course outline

ADVANCED CALCULUS

MODULE– I

DerivativesoffunctionsonR^n,Differentiationofcompositefunctions,Taylor'stheorem,Differentialforms.

PROJECT

A brief report on Taylor's Theorem.

MODULE– II

Theoremsof Green,Gauss&Stokes,

PROJECT

An over view on Green, Gauss & Stokes Theorem.

MODULE– III

Differentiation of Transformations, Linear functions and Transformations, Differential and Transformations.

MODULE– IV

Inverse of Transformations, Implicit function Theorems, Functional Dependence.

PROJECT

A project report on Implicit function Theorem.

MODULE– V

Set functions, Transformations and Multiple integrals, curves and Arc Length.

PROJECT

A discussion on curves and Arc length

MODULE– VI

Surfaces and surface area, integrals over curves and surfaces.

PROJECT

A note on integrals over curves.

MODULE– VII

Power Series, Improper integrals with parameters, The Gamma Function.

PROJECT

A brief report on Gamma function.

BOOKPRESCRIBED

1.Advanced calculus – R. C. Buck (Mc. Graw hill– Kogakusha Ltd.)Chapters:3 (3.3, 3.4, 3.5), 6 (6.3,6.4),7,8, 9 (9.2, 9.4, 9.5)

Course outline

NTON2483OPERATION RESEARCH

Subject Name	Code	Type of course	T-P-P (Credit)	Prerequisite
OPERATION RESEARCH	**NTON2483**	**Theory + Project**	**3-0-1**	**Nil**

Objective:

- To demonstration of the utilization of Linear Programming Problems in industry and business.
- To apply the inventory controls techniques in real application problem.
- To achieve good score in net examination.

Course outcome

Cos	Course outcomes
CO1	• Determining the extreme values of some real-world objective: the maximum (of profit, performance, or yield) or minimum (of loss, risk, or cost).
CO2	• Formulate the necessary and sufficient optimality conditions for linear programmingand demonstrate the geometrical interpretation of theseconditions.
CO3	• Use the mathematical foundations learned in this course to formulate new applicationsas optimal decision problems and seek appropriate solutionsalgorithms.
CO4	• Use of duality theory to solve the real-life application problems by reducing the large number of constraints.
CO5	• Can use various techniques to solve basic inventory and queuing theory problems.

Course Outline

Module-I:

Linear programming problem & Simplex method: Introduction to linear programming problem,Formulation of linear programming problem, Graphical solution of linear programming problem, Solution of linear programming problem using simplex method, Artificial variables, Solution of linear programming problem using Big-M and two-phase method

Module -II:

Duality in Linear Programming: Introduction, General primal-dual pair, formulating primal-dual problem, Duality in simplex method, Dual simplex method.

Module – III:

Inventory Controls: Introduction, Inventory decision, Cost associate with inventories, Factor affecting inventory control, Economic order quantity (EOQ).

Module - IV:

Deterministic inventory problem with no shortages, Deterministic inventory problem with shortages, Economic order quantity (EOQ) problem with price breaks.

Module – V:

Elementary queuing theory: Introduction, Queuing system, Elements of queuing system, Operating characteristics of queuing system.

Module – VI:

Probability distribution in queuing systems, Classification of queuing models, Definition of transient and steady state.

Module – VII:

Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.

Projects:

1. Project on Inventory management system
2. Project on queuing theory

Text Books:

1. KantiSwarup, P.K. Gupta and Man Mohan-Operations Research, S. Chand and Co. Pvt.Ltd.

2. Engineering Optimization Theory and Practice by Singiresu S. Rao, JOHN WILEY & SONS, INC., Fourth Edition

Reference Book:

1. Mathematical Programming by N. S. Kambo, East West Press.

Course outline

NTON2484 DESCRIPTIVE STATISTICS & DATA ANALYSIS

Subject Name	Code	Type of course	T-P-P (Credit)	Prerequisite
DESCRIPTIVE STATISTICS & DATA ANALYSIS	**NTON2484**	**Theory+Proj**	**3-0-1**	**Nil**

Objective:

- The primary objective of this course is to familiarize students with the fundamental concepts and techniques of probability theory and statistical analysis.
- The main objective of this course is to provide mathematical concepts and build up strong mathematical fundamentals to support many subjects of computer science engineering.
- To achieve the good score in NET examination

Learning Outcome:

Cos	Course outcomes
CO1	• Can achieve the concepts of sampling which can apply to business decision
CO2	• Can apply the concepts of discrete and continuous probabilitydistributions to make the prediction to the real-life application
CO3	• Compute probabilities based on practical situations using the Binomial, Poisson and Normal distributions.
CO4	• Can apply the analysis of variance and covariance in multivariate data
CO5	• Can apply the feature reduction techniques Principle component analysis, Discriminant analysis, Cluster analysis for prediction analysis

Course Outline

Module:1

Random variables and distributions functions (univariate and multivariate); Expectations and moments.Marginal and conditional distributions. Characteristic functions.

Module:2:
Standard discrete and continuous univariate distributions.Sampling distributions, Standard errors and asymptotic distributions, Distributions of order statistics and range.

Module:3
Simple non-parametric tests for one and two sample problems, Rank correlation and test for independence.

Module:4
Analysis of variance and covariance. Fixed, random and mixed effects models. Simple and multiple linear regression, Logistic regression.

Module:5
Multivariate normal distribution, Wishart distribution and their properties. Distributions of quadratic forms. Inference for parameters.

Module:6

Data reduction techniques: Principle component analysis, Discriminant analysis, Cluster analysis.

Module:7

Simple random sampling, stratified sampling and systematic sampling. Probability proportional to size sampling.

Projects:

Prepare a report on Gauss Markov models.

Prepare a report on correlation and regression analysis.

Text Book:

1. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications,7th Ed., Pearson Education, Asia, 2006.
2. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint,2007.
3. Devore, J. L.: Probability & Statistics for Engineering and the Sciences, 8th edition, Cengage Learning, 2012.

Reference Book:

1. Milton, J. S. and Arnold J. C.: Introduction to Probability and Statistics: Principles andApplicationsforEngineering and theComputing Sciences, 4th edition,Tata McGraw-Hill, 2007.
2. Johnson, R. A., Miller: Freund's Probability and Statistics for Engineers, 8th edition, PHI, 2010.
3. Meyer,P.L.:IntroductoryProbabilityandStatisticalApplications,2nd edition,AddisonWesley, 1970.
4. Ross, S. M.: Introduction to Probability Models, 11th edition, Academic Press, 2014.



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