CHARUSAT
CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

ACADEMIC REGULATIONS & SYLLABUS

P. D. Patel Institute of APPLIED SCIENCES

FACULTY OF SCIENCE
DEPARTMENT OF MATHEMATICAL SCIENCES
MASTER OF SCIENCE PROGRAMME (MATHEMATICS)

CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty of Science

ACADEMIC REGULATIONS

M.Sc. (Mathematics)

(Effective from A. Y. 2022-23)

Charotar University of Science and Technology (CHARUSAT)

CHARUSAT Campus, At Post: Changa – 388421, Taluka: Petlad, District: Anand

Phone: 02697-247500, Fax: 02697-247100, Email: info@charusat.ac.in

www.charusat.ac.in

Charotar University of Science and Technology (CHARUSAT)

FACULTY OF SCIENCE

ACADEMIC REGULATIONS

M.Sc. Programme

To ensure uniform system of education, duration of post graduate programmes, eligibility criteria for and mode of admission, credit load requirement and its distribution between course and system of examination and other related aspects, following are the academic rules and regulations.

1. System of Education

The Semester system of education shall be followed across the Charotar University of Science and Technology (CHARUSAT) at Master's levels. Each semester will be at least 90 working days duration. Every enrolled student will be required to do a specified course work in the chosen subject of specialization and also complete a project/dissertation if any. Medium of instruction will be English

2. Duration of Programme

Postgraduate programme	(M.Sc.)
Minimum	4 semesters (2 academic years)
Maximum	6 semesters (3 academic years)

The maximum limit can be extended by 1 or 2 semester subject to the approval of university on case to case basis.

3. Eligibility for admissions

For the admission to M.Sc., programs in the subject of Biological/Physical/Mathematical/ Chemical Sciences a candidate must have obtained a Degree of Bachelor of Science from any recognized University or a Degree recognized as equivalent there to, with minimum Second Class.

4. Mode of admissions

Admission to M.Sc. programme will purely on combined merit of admission test and performance at graduation.

5. Programme structure and Credits

A student admitted to a program should study the course and earn credits specified in the course structure. (Please refer Annexure-A)

6. Attendance

6.1 All activities prescribed under these regulations and listed by the course faculty members in their respective course outlines are compulsory for all students pursuing the courses. No exemption will be given to any student from attendance except on account of serious personal illness or accident or family calamity that may genuinely prevent a student from attending a particular session or a few sessions. However, such unexpected absence from classes and other activities will be required to be condoned by the Dean/Principal.

6.2 Student attendance in a course should be 80%.

7. Course Evaluation

7.1 The performance of every student in each course will be evaluated as follows:

7.1.1 Internal evaluation by the course faculty member(s) based on continuous assessment, for 30% of the marks for the course; and

7.1.2 Final examination will be conducted by the University for 70% of the marks for the course.

7.2 Internal Evaluation

7.2.1 Internal evaluation will be based on internal tests and several other tools of assessment like, quiz, viva, seminar etc., as prescribed by concerned teacher and decided by the faculty.

7.3 Internal Institutional evaluation for practical

7.3.1 One internal practical test/viva will be conducted per semester totalling to 30 % internal marks for practical

7.3.2 In “Continuous evaluation” Students shall be evaluated in a continuous manner for their involvement in the practical, aptitude for learning, completion of practical related assignments, regularity in the practical and record keeping

7.4 University Examination

7.4.1 The final examination by the University for 70% of the evaluation for the course will be through written paper or practical test or oral test or

presentation by the student or a combination of any two or more of these.

7.4.2 In order to earn the credit in a course a student has to obtain grade other than FF.

7.5 Performance at Internal & University Examination

7.5.1 Minimum performance with respect to internal marks as well as university examination will be an important consideration for passing a course. Details of minimum percentage of marks to be obtained in the examinations areas follows

Minimum marks in University Exam per subject	Minimum marks Overall per subject
40%	50%

7.5.2 If a candidate obtains minimum required marks per subject but fails to obtain minimum required overall marks, he/she has to repeat the university examination till the minimum required overall marks are obtained.(As per the clause 8.2 (iv))

8. Grading

8.1 The internal evaluation marks and final University examination marks in each course will be converted to a letter grade on a ten-point scale as per the following scheme:

Grading Scheme:

Range of Marks (%)	≥80	≥75 <80	≥70 <75	≥65 <70	≥60 <65	≥55 <60	≥50 <55	<50
Letter Grade	AA	AB	BB	BC	CC	CD	DD	FF
Grade Point	10	9	8	7	6	5	4	0

8.2 The student's performance in any semester will be assessed by the Semester Grade Point Average (SGPA). Similarly, his performance at the end of two or more consecutive semesters will be denoted by the Cumulative Grade Point Average (CGPA). The SGPA and CGPA are calculated as follows:

(i) SGPA = $\sum C_iG_i / \sum C_i$ where C_i is the number of credits of course i
G_i is the Grade Point for the course i
and i = 1 to n, n = number of courses in the semester

(ii) CGPA = $\sum C_iG_i / \sum C_i$ where C_i is the number of credits of course i
G_i is the Grade Point for the course i and i = 1 to n, n = number of courses of all semesters up to which CGPA is computed.

(iii) No student will be allowed to move further if CGPA is less than 3 at the end of every academic year.

9. Awards of Degree

9.1 Every student of the programme who fulfils the following criteria will be eligible for the award of the degree:

9.1.1 He/ She should have earned at least minimum required credits as prescribed in course structure; and

9.1.2 He/ She should have cleared all internal and external evaluation components in every course; and

9.1.3 He/ She should have secured a minimum CGPA of 5.0 at the end of the programme;

9.1.4 In addition to above, the student has to complete the required formalities as per the regulatory bodies.

9.2 The student who fails to satisfy minimum requirement of CGPA will be allowed to improve the grades so as to secure a minimum CGPA for award of degree. Only latest grade will be considered.

10. Award of Class:

The class awarded to a student in the programme is decided by the final CGPA as per the following scheme:

Award of Class	**CGPA Range**
First Class with Distinction	$7.50 \leq$ CGPA < 10.00
First class	$6.00 \leq$ CGPA < 7.50
Second Class	$5.00 \leq$ CGPA < 6.00
Pass Class	CGPA<5.00

11. Transcript:

The transcript issued to the student at the time of leaving the University will contain a consolidated record of all the courses taken, credits earned, grades obtained, SGPA,CGPA, class obtained, etc.

VISION

To become an eminent national institute imparting science education integrated with research.

MISSION

To engage in education, research, and spread of science for the benefit of society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Postgraduate would be able to

PEO-1: Apply the acquired knowledge in various fields of sciences to plan and execute tasks. (POs 1, 2, 3, 8)

PEO-2: Have scientific aptitude and competency in solving local and global problems. (POs 4, 6, 9, 10)

PEO-3 Possess an ethical approach, while executing research projects and scientific writing. (POs 7, 9, 10)

PEO-4 Ability to follow life-long learning. (POs 11)

PEO-5 Understand the importance of team work and possess leadership and entrepreneurship traits. (POs 5, 6, 8)

N.B. POs are mapped with PEOs.

PROGRAM OUTCOMES (POs)

The Programme Outcome are as under:

The Post Graduates would be able to

PO1. Knowledge in sciences: Possess knowledge and comprehend the various core and allied courses offered under the opted stream of sciences.

PO2. Planning Abilities: Demonstrate effective planning abilities, including time management, resource management, delegation skills, organizational skills, teamwork, and interpersonal skills.

PO3. Problem analysis: Utilize the principles of scientific enquiry and think analytically, critically with clarity of thought, while solving problems.

PO4. Modern tool usage: Apply appropriate methodologies, methods and procedures, resources to conceptualize the matters.

PO5. Leadership skills: Realize the importance of teamwork and take initiatives to plan and implement a workflow to fulfill tasks with a compassionate attitude.

PO6. Professional Identity: Establish as a professional in the chosen area of the profession with social responsibility**.**

PO7. Ethics in Science: To understand the value of being ethical and implement its principles while carrying out research and publication, tasks at workplace and in life. To respect and adhere to the rules/regulations/treaties/directives/notifications/laws related to scientific research and business.

PO8. Communication: Communicate effectively and responsibly with the scientific community and with society at large, such as being able to comprehend and write effective reports, make effective presentations and documentation, and give and receive clear instructions.

PO9. Modern Science and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety and legal issues and help society whenever situations arise.

PO10. Environment and sustainability: Understand the causes of environmental pollution and how it can be reduced and remedied using green technology in industries and environment.

PO11. Life-long learning: Vigilant about changes in the worldwide professional scenario arising out of technological, political, and economic factors. Recognize the need for and undertake steps necessary to fill the gaps recognized to keep oneself professionally competent. Self- assess and use feedback effectively from others to identify learning needs and to satisfy these needs on an ongoing basis.

CHOICE BASED CREDIT SYSTEM

With the aim of incorporating the various guidelines initiated by the University Grants Commission (UGC) to bring equality, efficiency and excellence in the Higher Education System, Choice Based Credit System (CBCS) has been adopted. CBCS offers wide range of choices to students in all semesters to choose the courses based on their aptitude and career objectives. It accelerates the teaching-learning process and provides flexibility to students to opt for the courses of their choice and / or undergo additional courses to strengthen their Knowledge, Skills and Attitude.

1. CBCS – Conceptual Definitions / Key Terms (Terminologies)

Types of Courses: The Programme Structure consist of 4 types of courses: Foundation courses, Core courses, Elective courses and Non-credit (audit) courses.

1.1. Foundation Course

These courses are offered by the institute in order to prepare students for studying courses to be offered at higher levels.

1.2. Core Courses

A Course which shall compulsorily be studied by a candidate to complete the requirements of a degree / diploma in a said programme of study is defined as a core course. Following core courses are incorporated in CBCS structure:

A. University Core courses (UC):

University core courses are compulsory courses which are offered across university and must be completed in order to meet the requirements of programme. Environmental science will be a compulsory University core for all Undergraduate Programmes.

B. Programme Core courses (PC):

Programme core courses are compulsory courses offered by respective programme owners, which must be completed in order to meet the requirements of programme.

1.3. Elective Courses

Generally, a course which can be chosen from a pool of courses and which may be very specific or specialised or advanced or supportive to the discipline of study or which provides an extended scope or which enables an exposure to some other discipline/domain or nurtures the candidates proficiency/skill is called an elective course. Following elective courses are incorporated in CBCS structure:

A. University Elective Courses (UE):

The pool of elective courses offered across all faculties / programmes. As a general guideline, Programme should incorporate 2 University Electives of 2 credits each (total 4 credits).

B. Institute Elective Course (IE)

Institute elective courses are those courses which any students of the University/Institute of a Particular Level (PG/UG) will choose as offered or decided by the University/Institute from time-to-time irrespective of their Programme /Specialisation

C. Programme Elective Courses (PE):

The programme specific pool of elective courses offered by respective programme.

D. Cluster Elective Course (CE):

An 'Elective Course' is a course which students can choose from the given set of functional course/ Area or Streams of Specialization options (eg. Common Courses to EC/CE/IT/EE) as offered or decided by the Institute from time-to-time.

1.4. Non Credit Course (NC) - AUDIT Course

A 'Non Credit Course' is a course where students will receive Participation or Course Completion certificate. This will be reflected in Student's Grade Sheet but the grade of the course will not be consider to calculate SGPA and CGPA.

Attendance and Course Assessment is compulsory for Non Credit Courses.

1.5. Medium of Instruction

The Medium of Instruction will be English.

M. Sc. (Mathematics)

Aim: To motivate and nurture young talent in the field of science through concept-based and inquiry-driven education, so that they can take up challenging research and teaching assignments in universities, R & D institutions and various industries.

Background:

Increasingly, in today's times, there is a growing emphasis on the interdisciplinary nature of science, and recognition of the importance of research experience. This is only possible if one can make the learning of basic sciences exciting through a creative and integrated approach to teaching. **The Charotar University of Science & Technology**, a university for future thinkers, started a M.Sc. degree course in Mathematics from the year 2017-18. The Programme focuses on the unified nature of science and aims to train some of the brightest young minds of our country, mentored by some of the best practitioners of science in India

The hall mark of the Programme:

- A comprehensive programme that will enable the students to understand the basic laws of nature and develop necessary skills to apply them to any desired area or discipline.
- Small student-to-teacher ratio.
- Modern research and scientific environment will help every student excel in the field of Mathematics.
- It integrates the conventional bachelors and masters' programmes into a more holistic science education experience.

Outline

- The courses offered during the semesters, I to IV are comprehensive courses in all areas of Mathematics. It would help them make an informed judgment to determine their real interest and their aptitude for a given subject.
- These courses are meant to give a flavor of the various approaches and analyses as well as to prepare them for advanced courses in later years for research.
- In the semesters III and IV, students can choose advanced courses based on their interest.

Intake: 20-30 Students

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF MATHEMATICAL SCIENCES

Syllabus

M. Sc. Mathematics (Semester I- II)

ANNTEXURE-A

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)								
Subjects of M.Sc.(Mathematics) Semester-1								
Subject Code	Subjects	Teaching scheme				Theory Evaluation		Total
		L+S[#]	P	Total hrs.	Total Credits	Institute	University	
MA711	Complex Analysis	4+1		5	4	30	70	100
MA712	Functions of Several Real Variables	3+1		4	3	30	70	100
MA713	Numerical Analysis	5+1		6	4	30	70	100
MA714	Ordinary Differential Equations	3+1		4	3	30	70	100
MA715	Topology -1	2+1		3	2	30	70	100
MA716	Problems and Exercises in Mathematics - 1	5+1		6	5	30	70	100
HS141.02E*	Foreign Languages-French	2		2	2	30	70	100
HS105.02E*	Academic Speaking and Presentation Skills	2		2	2	30	70	100
	Total			30	23			700

 # S = Seminar hours. These hours are not to be counted for credit hours.
***Student can choose any one**

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)								
Subjects of M.Sc.(Mathematics) Semester-2								
Subject Code	Subjects	Teaching scheme				Theory Evaluation		Total
		L+S#	P	Contact hrs.	Total Credits	Institute	University	
MA721	Algebra - 1	3+1		4	3	30	70	100
MA722	Differential Geometry	3+1		4	3	30	70	100
MA723	Linear Algebra	4+1		5	4	30	70	100
MA724	Partial Differential Equations	3+1		4	3	30	70	100
MA725	Real Analysis	3+1		4	3	30	70	100
MA726	Problems and Exercises in Mathematics - 2	5+1		6	5	30	70	100
HS106.02E	Academic Writing	2		2	2	30	70	100
	University Elective*	2		2	2	30	70	100
	Total			31	25			800

 # S = Seminar hours. These hours are not to be counted for credit hours

***to be offered from University**

Internal Evaluation: Internal evaluation will be done as under:

Name of examination	Number	Examination duration	Distribution of internal of 30 marks
Internal Test	Two	60 minutes	20
Quiz	At least two	5 to 30 minutes	05
Seminar	At least one	About 15 to 20 minutes	05

The evaluation will be done by the faculty members.

University examination:

There will be university examination at the end of the semester.

Remark:

Special interactive problem solving sessions will be conducted by respective faculty members on weekly bases. The courses are aimed to train the student to acquire the knowledge in higher mathematics which helps the student preparing for career in Higher Mathematics. More emphasize will be given to problem solving in each course.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

MA711: COMPLEX ANALYSIS

M. Sc. SEMESTER-I

Credits and Hours:

Teaching Scheme	Theory	Practical/Seminar	Total	Credit
Hours/week	4	1	5	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Basic Concept of Complex Analysis	04
2.	Analytic Functions	11
3.	Complex Integration	20
4.	Series Representation	25

Total hours: 60

B. Detailed Syllabus:

1	**Basic Concept of Complex Analysis 04 Hours**	**5%**
1.1	Algebraic properties of Complex numbers (sum, product, conjugate, exponential form, arguments of products and quotients, roots of complex number)	**1**
1.2	Representations of complex numbers. Regions in the complex plain	**1**
1.3	Functions and mappings, limits, continuity and derivatives	**2**
2	**Analytic Functions 11 Hours**	**25%**
2.1	Cauchy- Riemann equations (in Cartesian and polar form).	**2**
2.2	Analytic functions	**2**
2.3	Harmonic functions	**2**
2.4	Power series and analytic functions	**2**
2.5	Exponential and Logarithmic functions. Branches and derivatives of Logarithmic function, identities involving Logarithms	**2**
2.6	The power function. The trigonometric functions sine and cosine. Hyperbolic functions. Inverse trigonometric and hyperbolic functions.	**1**

3	**Complex Integration 20 Hours**	**33%**
3.1	Contour, contour integrals, anti-derivative	**4**
3.2	Cauchy-Goursat Theorem, simply and multiply connected domains	**4**
3.3	Cauchy's Integral Formula, Extension of the Cauchy's Integral Formula.	**4**
3.4	Morera's theorem, Cauchy's inequality. Liouville's theorem,	**4**
3.5	Fundamental theorem of Algebra. Maximum modulus principle.	**4**
4.	**Series Expansion 25 Hours**	**37%**
4.1	Taylor's theorem, Laurent series	**4**
4.2	Absolute and uniform convergence of power series	**3**
4.3	Residue. Residues theorem	**4**
4.4	Types of Isolated singularities, residues at poles, zeros of analytic function	**3**
4.5	Evaluation of improper real integrals	**4**
4.6	Improper integrals from Fourier Analysis	**2**
4.7	Mobius transformations, Conformal Mappings	**5**

C. Instructional Method and Pedagogy:

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Attendance is compulsory in lectures/laboratory which carries a 5% component of the overall evaluation.
- Minimum two internal exams will be conducted and average of two will be considered as a part of 15% overall evaluation.
- Assignments based on course content will be given to the students at the end of each unit/topic and will be evaluated at regular interval. It carries a weighting of 5%.
- Two Quizzes (surprise test) will be conducted which carries 5% component of the overall evaluation.

D. Course Outcomes (COs):

At the end of the course, the students will be able to

CO1	describe and dissect many core concepts of Complex Analysis and solve many complex integration
CO2	apply the concepts of this course to learn some other courses of Mathematics like Functional Analysis, Banach Algebras, Harmonic Analysis etc.
CO3	apply the concepts developed in this course in several branches of engineering.
CO4	develop their communication skills and an academic practice through self-prepared seminars of complex analysis.
CO5	develop their academic leadership through problem solving sessions of complex analysis
CO6	develop and enhance their ability of critical and clear thinking and their planning ability through the proof of the results of complex analysis.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	-	-	-	3	3	3
CO2	3	-	3	3	-	-	-	-	3	-	3
CO3	3	-	3	3	3	-	-	-	3	-	3
CO4	3	-	-	-	-	-	-	3	-	-	3
CO5	3	-	-	-	-	3	-	-	-	-	3
CO6	3	3	3	3	-	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

E. Recommended Study Material:

Text Books:

1. J. W. Brown and R. V. Churchill; Complex Variables and Applications, McGraw-Hill Education (2009) ninth edition.

Reference Books:

1. S. Ponnusamy; Foundation of Complex Analysis, Narosa Publ. House, New Delhi (1995).
2. J. B. Conway; Functions of One Complex Variables, Narosa Publ. House, New Delhi (1995) (Second Edition).
3. B. Chaudhary; The Elements of Complex Analysis, Wiley Eastern Ltd. New Delhi (1992) Second Edition.

URL Links:

https://en.wikipedia.org/wiki/Complex_analysis

http://mathworld.wolfram.com/ComplexAnalysis.html

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

MA712: FUNCTIONS OF SEVERAL REAL VARIABLES

M. Sc. SEMESTER - I

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	3	1	4	3
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Geometry of the Euclidean Space R^n.	09
2.	Differentiations.	20
3.	Integrations.	16
	Total hours:	45

B. Detailed Syllabus:

1	**Geometry of the Euclidean Space R^n: 09 Hours**	**20%**
1.1	R^n as a vector space.	
1.2	Inner product and Euclidian norm on the Euclidian space R^n.	
1.3	Limit, continuity of functions from R^m to R^n.	
2	**Differentiation : 20 Hours**	**45%**
2.1	Differentiation of functions from R^m to R^n.	
2.2	Basic properties of differentiation of functions from R^m to R^n. Chain Rule.	
2.3	Jacobian matrix. Partial derivatives.	
2.4	Directional derivatives and their relationship with differentiability of a function from R^m to R^n.	
2.5	Continuously differentiability of functions from R^m to R^n.	
2.6	Implicit function Theorem.	

2.7	Inverse function theorem.	
3	**Integration** **16 Hours**	**35%**
3.1	Tensor products.	
3.2	Fields and forms.	
3.3	Exterior derivatives, closed and exact forms.	
3.4	Poincare Lemma.	
3.5	Singular chain.	
3.6	Stokes' theorem.	

C. Instructional Method and Pedagogy:

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in last lecture.
- At the end of the lecture, teacher will say the topic he/she planned to cover in the next lecture.

D. Course Learning Outcomes:

At the end of the course, the students will be able to

CO1	analyze and use fundamental concepts to solve core problems of several variable calculus in modern science
CO2	recognize patterns and determine appropriate techniques for solving a variety of complex problems of multivariable functions
CO3	classify and determine lifelong problems in various branches of engineering
CO4	create and enhance their ability of the critical and clear thinking and ability of planning through the proof of the theorems, lemmas etc. covered in this course.
CO5	develop their academic leadership through discussion in a group to solve exercises and quires of the course. Students will be able to develop their communication skills and academic practices through self- prepared seminars.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	3	-	-	-	-	3	-	-
CO2	3	3	-	3	-	-	-	-	-	-	-
CO3	3	-	3	3	-	-	-	-	-	-	3
CO4	3	3	-	3	-	-	-	-	-	-	-
CO5	3	-	-	-	3	3	-	3	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

E. Recommended Study Material:

Text Books:

1. G. Spivak; Calculus on Manifolds, W. E. Benjamin (1965).

Reference Books:

1. S. R. Ghorpade and B. V. Limaye; A Course in Multivariable Calculus and Analysis.
2. W. Rudin; Principle of Mathematical Analysis, Tata McGrow Hill Publ. (1983) third edition.
3. S. Kantorovitz; Several Real Variables, Springer Undergraduate Mathematics Series (2016).
4. M. Moskowitz; Functions of Several Real Variables, World Scientific (2011)

URL Links:

https://www.maths.tcd.ie/~ignateva/23212Proofs.pdf

https://en.wikipedia.org/wiki/Function_of_several_real_variables

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – I

MA713: NUMERICAL ANALYSIS

Credits and Hours:

Teaching Scheme	Theory	Practical	Seminar	Total	Credit
Hours/week	5	-	**1**	6	4
Marks	100	-		100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Approximate solutions of nonlinear equations and system of linear equations	12
2.	Interpolation	12
3.	Numerical Integration and Differentiation	09
4.	Numerical solutions of differential equations	12
5.	Practical	15
	Total hours	**60**

B. Detailed Syllabus:

1	**Approximate solutions of nonlinear equations and system of linear equation:** **12 Hours**	**26%**
1.1	Method of iteration, Bisection method, Regula - Falsi methods	
1.2	Secant method, Newton-Raphson method, Rate of convergence of these methods	
1.3	Gauss elimination method and its applications	
1.4	Gauss-Seidal method.	
2	**Interpolation:** **12 Hours**	**27%**
2.1	Finite differences	
2.2	Lagrange, Hermite, Newton interpolations	
2.3	Spline interpolation	

2.4	Uniqueness of interpolation polynomial	
2.5	Applications of interpolation.	
3.	**Numerical Integration and Differentiation: 09 Hours**	**20%**
3.1	Newton–Cotes Quadrature	
3.2	Romberg Integration and Gaussian Quadrature	
3.3	Numerical Differentiation	
4.	**Numerical solutions of differential equations: 12 Hours**	**27%**
4.1	Euler's method, Picard's method	
4.2	Modified Euler's method, Runge – Kutta's methods (of order 2 and 4)	
4.3	Multistep methods : Milne's method	
4.4	Adams-Bashfourth'smethod , Adams-Moulton's method.	

C. Instructional Method and Pedagogy:

- At the starting of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, the teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, the teacher will say the topic he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	construct algorithms and write programs for numerical methods and analyze errors in the computed results.
CO2	evaluate out the approximate solution of single-variable equations and systems of linear equations using numerical methods.
CO3	determine the solution of interpolation theory and applications in numerical calculus to analyze real-world problems.
CO4	solve numerically the initial valued problem of ordinary differential equation for the scientific problems.

CO5	develop their academic leadership through discussion in a group and self-prepare seminar.
CO6	solve the problems of competitive examinations like UGC-NET, GATE, NBHM related to Numerical methods.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	-	3	3	3	-	-	-	-	-	3
CO3	3	-	3	3	3	-	-	-	-	3	3
CO4	3	-	3	3	3	-	-	-	-	3	3
CO5	3	-	-	-	-	3	3	-	-	-	3
CO6	3	-	3	3	3	-	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

1. S. D. Conte and C. de Boor; Elementary Numerical Analysis, McGrow Hill (1980) Third Edition.

Reference Books:

1. Sastry S. S., "Introductory Methods of Numerical Analysis", Prentice Hall of India.
2. A. Iserles; A First Course in the Numerical Analysis of Differential Equations, Cambridge University Press (1996)
3. S. A. Mollah; Numerical Analysis and Computational Procedures, Books and Allieds (P) Ltd. (1996)
4. K. Atkinson and W. Han; Elementary Numerical Analysis, Third Edition (2004).

URL Links:

http://mathworld.wolfram.com/NumericalAnalysis.html

https://en.wikipedia.org/wiki/Numerical_analysis

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – I

M714: ORDINARY DIFFERENTIAL EQUATIONS

Credits and Hours:

Teaching Scheme	Theory	Practical	Total	Credit
Hours/week	3	1	4	3
Marks	100	-	100	

A. Outline of the Course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Second order linear differential equations	13
2.	Series solutions of first and second order equations	16
3.	Systems of first order differential equations & existence and uniqueness of solution of differential equations	10
4.	Existence and uniqueness of solution of differential equations:	06
	Total hours:	**45**

B. Detailed Syllabus:

1.	**Second order linear differential equations:**	**13 Hours**	**28%**
1.1	Introduction of second order linear differential equations		
1.2	General solution of homogeneous equation		
1.3	Other solution by using known solutions		
1.4	Homogeneous equations with constant coefficients		
1.5	Method of undetermined coefficients		
1.6	Method of variation of parameters		
2.	**Series solutions of first and second order equations:**	**16 Hours**	**36%**
2.1	Ordinary points		

2.2	Singular points	
2.3	Regular singular points	
2.4	Gauss's hypergeometric equation	
2.5	The point at infinity	
3.	**Systems of first order differential equations: 10 Hours**	**22%**
3.1	Linear systems	
3.2	Homogeneous linear systems with constant coefficients	
3.3	Nonlinear systems	
4.	**Existence and uniqueness of solution of differential equations: 06 Hours**	**14%**
4.1	The method of successive approximations	
4.2	Picard's theorem	

C. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	solve ordinary differential equations arise in physical and engineering sciences
CO2	keen the practical importance of solving differential equations
CO3	solve systems of linear first-order differential equations
CO4	use series methods to solve Bessel, hypergeometric and Legendre equations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	-	3	3	3	3	3	3
CO3	3	-	3	3	-	3	3	3	3	3	3
CO4	3	-	3	3	-	3	-	3	-	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

D. Instructional Method and Pedagogy:

- At the starting of course, the course delivery pattern, prerequisite of the subject will be discussed

- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, the teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, the teacher will say the topic he/she planned to cover in the next lecture.

E. Recommended Study Material:

Text Books:

1. G. F. Simmons; Differential Equations and Applications with Historical notes, Taylor& Francis Group, CRC Press (2017) Third Edition.

Reference book:

1. E. A. Coddington; Introduction to Ordinary Differential Equations, Dover Publishing, INC, New York (1961).
2. A. L. Rabenstein; Introduction to Ordinary Differential Equations, Academic Press (1966).
3. D. Somasundaram; Differential Equations, Narosa Publ. New Delhi (2002).
4. M. D. Raisinghania; Advanced Differential Equations, Khanna Publ. New Delhi (2002).
5. S. G. Deo and V. Raghavendra; Ordinary Differential Equations and Stability Theory, Tata McGrow Hill Publ. Co. Ltd. (1980).

URL Links:

http://mathworld.wolfram.com/topics/OrdinaryDifferentialEquations

https://en.wikipedia.org/wiki/Ordinary_differential_equation

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – I

MA715: TOPOLOGY - 1

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	2	1	3	2
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Some concepts of Set Theory	6
2.	Metric Space	10
3.	Completeness	6
4.	Compactness	8
	Total hours:	**30**

B. Detailed Syllabus:

1.	**Some concepts of Set Theory: 6 Hours**	**20%**
1.1	Elementary set theory, finite, countable and uncountable sets	
1.2	Partially ordered sets, Zorn's lemma.	
2.	**Metric Space: 10 Hours**	**33%**
2.1	The Inequalities of Young, Holderand Minkowski	
2.2	Metric spaces and examples. Equivalent metrics	
2.3	Interior point, limit point and boundary point of a subset of a metric space	
2.4	Open sets and closed sets in a metric space	
2.5	Cauchy and convergent sequences in a metric space	
2.6	Continuous and uniformly continuous functions	
2.7	Spaces of continuous functions.	
3.	**Completeness: 6 Hours**	**20%**

3.1	Completeness of a metric space		
3.2	Baire's theorem.		
3.	**Compactness:**	**8 Hours**	**27%**
4.1	Compactness for metric spaces		
4.2	Ascoli's theorem.		

C. Instructional Method and Pedagogy:

- At the starting of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, the teacher will recall what he/she covered in last lecture.
- At the end of the lecture, the teacher will say the topic he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	understand and visualize the concept of Metrics (distance) in real world
CO2	understand many core concepts of Metric Spaces.
CO3	apply the concepts of this course to Functional Analysis, Real Analysis and Complex Analysis.
CO4	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO5	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars.
CO6	through the proof of the theorems, lemmas etc. covered in this course, students will be able to develop and enhance their ability of critical and clear thinking and ability of planning

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	3	-	-	-	-	-	-	3
CO2	3	-	-	3	-	-	-	-	-	-	3
CO3	3	-	3	-	-	-	-	-	-	-	3
CO4	3	-	3	3	-	3	-	3	-	-	3
CO5	3	3	3	3	-	-	3	3	-	-	3
CO6	3	3	3	3	-	-	-	3	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

1. G. F. Simmons; Introduction to Topology and Modern Analysis, Tata McGrow Hill Publ. Co. Ltd.

Reference Books:

1. J. Munkers; Topology: A First course, Prentice Hall of India Pvt. Ltd. New Delhi.
2. R. R. Goldberg; Methods of Real Analysis, Oxford & IBH Publ. Ltd. ; Several Real Variables, Springer Undergraduate Mathematics Series (2016).
3. M. O'Searcoid; Metric Spaces, Springer Undergraduate Mathematics Series(2001)
4. J. Heinonen; Lectures on Analysis on Metric Spaces, Springer (2001)
5. Mícheál O'Searcoid ; Metric Spaces , springer (2007)
6. S. Shirali, H. L. Vasudeva; Metric Spaces, Springer (2006)

URL Links:

http://www.topologywithouttears.net/topbook.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – I

MA716: Problems and Exercises in Mathematics – 1

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	5	1	6	5
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Complex Analysis	15
2.	Functions of Several Real Variables	15
3.	Numerical Analysis	15
4.	Ordinary Differential Equations	15
5.	Real Analysis and	15
	Total	**75**

B. Detailed Syllabus:

1.	Problems and Exercises in Complex Analysis	**15 Hours**	**20%**
2.	Problems and Exercises in Functions of Several Real Variables	**15 Hours**	**20%**
3.	Problems and Exercises in Numerical Analysis	**15 Hours**	**20%**
4.	Problems and Exercises in Ordinary Differential Equations	**15 Hours**	**20%**
5.	Problems and Exercises in Real Analysis and Topology 1	**15 Hours**	**20%**

C. Instructional Method and Pedagogy:

- At the start of course, teacher will say to the students the importance of this course.
- In this course, emphasizes will be given to problem solving.
- At the starting of the lecture, teacher will recall which problems was discussed in last session.

- At the end of the lecture, teacher will give some problems to discuss in the next session.
- The teacher will solve some problems in the class.
- Students will solve problems in the class with the help of the faculty members.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	understand the theory part of courses they have studied
CO2	enhance his/her thinking which would be helpful to them who are preparing for competitive examinations.
CO3	encouraged/ inspired to go for research in Mathematics
CO4	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO5	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	3	3	-	-	-	-	-	-	3
CO2	3	-	3	3	-	-	-	-	-	-	3
CO3	3	-	3	3	-	-	-	-	-	-	3
CO4	3	-	3	3	-	3	-	-	-	-	3
CO5	3	-	3	3	-	3	3	3	-	-	3
CO6	3	-	3	3	-	3	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

All books mentioned in above syllabus of Semester I as text books.

Reference Books:

All books mentioned in above syllabus Semester I as reference books.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY
FACULTY OF MANAGEMENT STUDIES
DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

HS105.02 E: ACADEMIC SPEAKING AND PRESENTATION SKILL **(Sem.-I)**

1. Credits and Schemes:

Sem.	Course Code	Course Name	Credits	Teaching Scheme	Evaluation Scheme				
				Contact Hours/Week	Theory		Practical		Total
					Internal	External	Internal	External	
1	HS105.02 E	Academic speaking and presentation skill	02	02	--	--	30	70	100

2. Course Outline

Module No.	Title/Topic	Classroom Contact Hours
1	**Foundations of Advance Communication** • Meaning and Definition of Advance Communication • Advance Communication in Digital, Social, Mobile World • Strategies for Advance Communication • Meaning and Concept of Academic Language • High Frequency Academic Vocabulary	**04**
2	**Art of Conversation** • Describing people, places and things • Expressing opinions • Making suggesting • Persuading someone • Interpreting and Summarizing	**06**
3	**Science of Power Speaking** • Phonemes • Word Stress • Pronunciation • Intonation • Pause • Register	**06**

	• Fluency • Prosody • Lexical Range	
4	**Academic Speaking Application – Part I** • Art of Oratory • Formal Presentation • Speech Analysis – Decoding Best Speeches	**08**
5	**Academic Speaking Application – Part II** • Job Interview • Group Discussion • Meeting	**06**
	Total	**30**

Instruction Methods and Pedagogy

The course is based on practical learning. Teaching will be facilitated by reading material, discussion, task-based learning, projects, assignments and various interpersonal activities like case studies, group work, independent and collaborative research, presentations etc.

I. Evaluation

The students will be evaluated continuously in the form of their consistent performance throughout the semester. There is no theoretical evaluation. There is just practical evaluation. The evaluation (practical) is schemed as 30 marks for internal evaluation and 70 marks for external evaluation.

Internal Evaluation

The students' performance in the course will be evaluated on a continuous basis through the following components:

Sl. No.	Component	Number	Marks per incidence	Total Marks
1	I-Talk	1	10	25
2	Situational Speaking	1	05	
3	Case Study - Speech Analysis	2	10	
4	Attendance and Class Participation	-		05
			Total	**30**

External Evaluation

The University Practical Examination will be for 70 marks and will test the advance communication skills and academic speaking.

Sl. No.	Component	Number	Marks per incidence	Total Marks
1	Viva / Practical	-	70	70
			Total	**70**

Course Outcome (COs):

After completion of the course the student would :

CO1	understand and demonstrate advance communication skills and academic speaking.
CO2	demonstrate linguistic competence
CO3	demonstrate performing ability at group discussion and personal interview.
CO4	demonstrate the formal presentation skills.
CO5	demonstrate ability to communicate in diverse situations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	-	-	-	3	-	-	2
CO4	-	-	-	-	-	-	-	3	-	-	-
CO5	-	-	-	-	-	-	-	3	-	-	-

Correlation levels 1, 2 or 3 are as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Reference Books

- Headway Academic Skills - Level 1: Listening, Speaking and Study Skills Student's Book Paperback

Reading

- **Unit 1:** Business communication Today (Thirteenth Edition) by Courtland L. Bovee, John V. Thill and Roshan Lal Raina
- **Unit 2:** Effective Speaking Skills by Terry O' Brien
- **Unit 2:** Speak Better Write Better by Norman Lewis
- **Unit 2:** Well Spoken: Teaching Speaking to All Students by Erik Palmer
- **Unit 3:** Let Us Hear Them Speak : Developing Speaking – Listening Skills in English by Jayshree Mohanraj (Publisher – Sage Publication)
- **Unit 4:** The craft of scientific presentations: Critical steps to succeed and critical errors to avoid. New York: Springer by Michael Alley
- **Unit 4:** Presentation Skills in English by Bob Dignen (Publisher: Orient Black Swan)

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – II

MA721: ALGEBRA - 1

Credits and Hours:

Teaching Scheme	Theory	Practical/Seminar	Total	Credit
Hours/week	3	1	4	3
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Concepts of Number Theory	6
2.	Groups and subgroups	6
3.	Homomorphism	6
4.	Automorphisms	4
5.	Permutations	6
6.	Conjugation	5
7.	Sylow's theorem	5
8.	Some special types of groups	7
	Total hours	**45**

B. Detailed Syllabus:

1	**Concepts of Number Theory: 06 Hours**	**13%**
1.1	Euclid's Algorithm.	
1.2	Divisibility of integers and fundamental theorem of arithmetic	
1.3	Congruence	
1.4	Chinese remainder theorem	
1.5	Euler's function φ.	
2	**Groups and subgroups: 06 Hours**	**14%**

21	Groups and subgroups and examples		
2.2	Finite groups		
2.3	Lagrange's Theorem and its applications		
2.4	Normal subgroups and quotient groups.		
3	**Homomorphism:**	**06 Hours**	**13%**
3.1	Homomorphism and Homomorphism theorems		
3.2	Cauchy's theorem for abelian groups		
3.3	Sylow's theorem for abelian groups		
4	**Automorphisms:**	**04 Hours**	**09%**
4.1	Automorphisms		
4.2	Cayley's theorem.		
5	**Permutations:**	**06 Hours**	**14%**
5.1	Product of permutations		
5.2	Cycles, Transpositions, Even Odd permutations		
5.3	permutation groups.		
6	**Conjugation:**	**05 Hours**	**11%**
6.1	Conjugate classes		
6.2	class equation and applications.		
7	**Sylow's theorem**	**05 Hours**	**11%**
7.1	Sylow's theorem		
7.2	Applications of Sylow's theorem.		
8	**Some special types of groups:**	**7 Hours**	**15%**
8.1	Simple groups		
8.2	Solvable groups.		

C. Instructional Method and Pedagogy:

- At the starting of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing boardor multi-media projector or OHP etc.
- At the starting of the lecture, the teacher will recall what he/she covered in the last lecture.

- At the end of the lecture, the teacher will say the topic he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	understand many core concepts of Elementary Number Theory and Group Theory.
CO2	apply concepts this course to Cryptology. They can apply their skill to Artificial (informal) Languages as well as Artificial Intelligence
CO3	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO4	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars.
CO5	Enhance the concepts of this course to Linear Algebra, Ring and Field theory
CO6	through the proof of the theorems, lemmas etc. covered in this course, students will be able to develop and enhance their ability of critical and clear thinking and ability of planning

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	3	-	-	-	-	-	-	3
CO2	3	3	-	3	3	-	-	-	-	-	3
CO3	3	-	3	3	-	3	-	-	-	-	3
CO4	3	-	3	3	-	3	3	3	-	-	3
CO5	3	-	-	3	-	-	-	-	-	-	3
CO6	3	3	3	3	-	-	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

I.N. Herstein;- Topics in Algebra (2nd Edition, 1975).

Reference Books:

1. I.N. Herstein; Abstract Algebra, Prentice Hall (1996), Third Edition

2. J.B. Fraleigh; A first course in abstract algebra (Narosa, 3rd Edition, 1983).
3. D. M. Burton; Elementarynumber theory, Universal Book Stall, New Delhi (Second Edition) .
4. D. J. S. Robinson; A Course in the Theory of Groups, Springer (1995)
5. J. F. Humphreys; A Course in Group Theory, Oxford University Press, (2001)

URL Links:

http://www.math.mtu.edu/~kreher/ABOUTME/syllabus/GTN
http://www.jmilne.org/math/CourseNotes/GT.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – II

MA722: DIFFERENTIAL GEOMETRY

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	3	1	4	3
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Curves in the plane and space:	11
2.	Three dimensional Geometry	10
3.	Curvature and Geodesic	18
4.	Gauss' Theorema Egregium	6
	Total hours	**45**

B. Detailed Syllabus:

1	**Curves in the plane and space: 11 Hours**	**24%**
1.1	Curves in the plane and space	
1.2	Parameterization	
1.3	Curvature, torsion and signed curvature	
1.4	Frenet-Serret equations	
1.5	Isoperimetric Inequality.	
2	**Three dimensional Geometry 10 Hours**	**22%**
2.1	Surfaces in three dimensions:	
2.2	Smooth surfaces, smooth maps, tangent and normal	
2.3	Lengths of curves on surfaces	
2.4	Isometries of surfaces	
2.5	Conformal mappings of surfaces	

3	**Curvature and Geodesic 18 Hours**	**40%**
3.1	Second fundamental form	
3.2	Normal and geodesic curvature	
3.3	Gaussian and mean curvatures	
3.4	Principal curvatures of a surface	
3.5	Geodesic and its properties	
3.6	Geodesic equation.	
4	**Gauss' Theorema Egregium 6 Hours**	**14%**
4.1	The Gauss and Codazzi - Mainardi equations,	
4.2	Gauss's theorem.	

C. Instructional Method and Pedagogy:

- At the starting of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- The teacher will show some of computer generated three dimensional figures and concepts.
- At the starting of the lecture, the teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, the teacher will say the topic he/she planned to cover in the next lecture.

D. Course Outcomes (COs):

At the end of the course, the students will be able to

CO1	analyze the geometrical primarily by focusing on the theory of curves and surface theory in modern science
CO2	apply classical lifelong problem-solving techniques of differential geometry in physics, engineering or other mathematical contexts
CO3	classify and apply concepts of differential geometry in various research fields using modern tools
CO4	find the solutions of the exercises and problems, the students have to analyze it first to solve. Students will be able to develop their communication skills and academic practices through self- prepared seminars.

CO5	develop their academic leadership through discussion in a group to solve exercises and quires of the course.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	-	-	-	-	-	3	-	-
CO2	3	-	3	3	-	-	-	-	-	-	3
CO3	3	-	3	-	-	-	-	-	-	-	-
CO4	-	3	3	3	-	3	-	3	-	-	-
CO5	-	-	-	3	3	-	-	-	-	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

Andrew Pressly; Elementary Differential Geometry, SUMSeries, (2004).

Reference Books:

1. Goetz ; Introduction to Differential Geometry, Addison Wesley, Publ. Co., (1970).
2. C. E. Weatherburn; Differential Geometry in Three Dimensions, Cambridge University Press, (1964).
3. C. C. Hsiung; A First Course in Differential Geometry, John Wiley and Sons (1981)
4. E. D. Bloch; A First Course in Geometric Topology and Differential Geometry, Birkhauser (1997)
5. M. Spivak; A Comprehensive Introduction to Differential Geometry, Publish or Perish, INC (1999)

URL Links:

https://en.wikipedia.org/wiki/Differential_geometry

http://people.math.gatech.edu/~ghomi/LectureNotes/

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY
FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – II

MA723: LINEAR ALGEBRA

Credits and Hours:

Teaching Scheme	Theory	Practical/Seminar	Total	Credit
Hours/week	4	1	5	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Vector spaces	14
2.	linear transformations and Matrices	16
3.	Canonical forms of linear transformations:	16
4.	Trace and Determinants:	9
5.	Quadratic forms:	5
	Total Hours	**60**

B. Detailed Syllabus:

1	**Vector spaces** **14 Hours**	**24%**
1.1	Vector spaces and examples	
1.2	Subspaces	
1.3	Linear dependence, basis and dimension.	
1.4	Dual space.	
2	**linear transformations and Matrices** **16 Hours**	**27%**
2.1	The algebra of linear transformations	
2.2	Characteristic roots	
2.3	Matrix representation of linear transformations, and change of basis.	
3	**Canonical forms of linear transformations:** **16 Hours**	**26%**
3.1	Canonical triangular forms	
3.2	Canonical forms of a Nilpotent linear transformation.	

3.3	Decomposition of a finite dimensional vector space: Jordan forms	
4	**Trace and Determinants: 9 Hours**	**15%**
4.1	Trace and transpose	
4.2	Determinants.	
5	**Quadratic forms: 5 Hours**	**08%**
5.1	Reduction and classification of quadratic forms.	

C. Instructional Method and Pedagogy:

- At the starting of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing boardor multi-media projector or OHP etc.
- At the starting of the lecture, the teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, the teacher will say the topic he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	apply the concepts of this course to Computer Engineering / Information Technology, Physics
CO2	apply the concepts of this course in the study of Functional Analysis, Banach Algebras and Field Theory.
CO3	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars.
CO4	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO5	through the proof of the theorems, lemmas etc. covered in this course, students will be able to develop and enhance their ability of critical and clear thinking and ability of planning

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	3	3	3	-	-	-	-	-	3
CO2	3	-	3	3	-	-	-	-	-	-	3
CO3	3	-	3	3	-	-	-	-	-	-	3
CO4	3	3	3	3	-	-	3	3	-	-	3
CO5	3	3	3	3	-	3	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

I.N. Herstein;- Topics in Algebra (2nd Edition, 1975).

Reference Books:

1. S. Kumaresan; Linear Algebra: A Geometric Approach, Prentice Hall Of India, (2000).
2. Helson; Linear Algebra, Hindustan Book Agency, Trim-4, (Second Edition) (1994).
3. J. H. Kwak And S. Hong; Linear Algebra, Birkhauser (Second Edition)
4. P. R. Halmos; Finite Dimensional Vector Spaces, Van Nostrand East-West Press
5. R. R. Stoll; Linear Algebra And Matrix Theory, Dover Publications, Inc., New York (1952)

URL Links:

https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/index

https://betterexplained.com/articles/linear-algebra-guide/

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – II

MA724: PARTIAL DIFFERNTIAL EQUATIONS

Credits and Hours:

Teaching Scheme	Theory	Practical	Total	Credit
Hours/week	3	1	4	3
Marks	100	-	100	

A. Outline of the Course:

Sr. No.	Title of the unit	Minimum number of hours
1.	First Order Partial Differential Equations	15
2.	Second Order Partial Differential Equations	15
3.	Wave, Laplace and Heat equations	15
	Total hours:	**45**

B. Detailed Syllabus:

1	**First Order Partial Differential Equations: 15 Hours**	**33%**
1.1	Origins of First order Partial Differential Equations	
1.2	Cauchy's Problem for First order Equations	
1.3	Linear Equations of the First Order	
1.4	Pfaffian Differential equations	
1.5	Nonlinear Partial Differential Equations of the First Order	
1.6	Compatible Systems of First order Equations	
1.7	Charpit's Method	
1.8	Jacobi's Method.	
2	**Second Order Partial Differential Equations: 15 Hours**	**33%**
2.1	The Origin of Second order Equations	
2.2	Linear Partial Differential Equations with Constant Coefficients,	
2.3	Equations with Variable Coefficients,	

2.4	Classification of second order Partial Differential Equations and canonical form.		
2.5	The Solution of Linear Hyperbolic Equations,		
2.6	Separation of Variables.		
2.7	Nonlinear equation of second order.		
3	**Wave, Laplace and Heat equations:**	**15 Hours**	**34%**
3.1	Wave Equation, vibration of different type of strings		
3.2	Laplace equation: Boundary Value Problems		
3.3	Separation of Variables		
3.4	Dirichlet and Neumann problems		
3.5	Solutions of Heat equations.		

C. Instructional Method and Pedagogy:

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing boardor multi-media projector or OHP etc.
- Teacher will show some of computer generated three dimensional figures and concepts.
- At the starting of the lecture, teacher will recall what he/she covered in last lecture.
- At the end of the lecture, teacher will say the topic he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	solve partial differential equations arise in physical and engineering sciences
CO2	solve linear Partial Differential with different methods
CO3	classify partial differential equations and transform into canonical form
CO4	identify real phenomena as models of partial derivative equations.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3
CO3	3	__	3	3	---	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

1. N. Sneddon; Elements of Partial Differential Equations, McGraw- Hill Publ. Co., (1957).
2. T. Amarnath; Elementary Course in Partial Differential Equations, Narosa Publ. House, New Delhi, (1997).

Reference Books:

1. Phoolan Prasad and R. Ravindran; Partial Differential Equations, Wiley Eastern
2. Qing Han; A basic course in partial differential equations , The American Mathematical Society (2011).
3. Z. Rubinstein; A Course in Ordinary, Academic Press (1969)
4. H. F. Weinberger; Partial Differential Equations with complex variables and Transform Method, Dover Publications, INC (1965)

URL Links:

http://tutorial.math.lamar.edu/Classes/DE/IntroPDE.aspx

http://nptel.ac.in/courses/111103021/5

http://www.math.uni-leipzig.de/~miersemann/pdebook.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

MA725: REAL ANALYSIS - 1

M. Sc. SEMESTER - II

Credits and Hours:

Teaching Scheme	Theory	Practical/Seminar	Total	Credit
Hours/week	3	1	4	3
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Measurable sets and Functions	**15**
2.	Lebesgue Integration	**15**
3.	Some classes of functions	**15**
	Total Hours	45

B. Detailed Syllabus:

1	**Measurable sets and Functions: 15 Hours**	**33%**
1.1	Algebra and σ-algebra of sets, Borel sets in R	
1.2	Lebesgue outer measure in R	
1.3	Measurable sets and Lebesgue measure on R	
1.4	Non-measurable set	
1.5	Measurable functions	
1.6	Sums, Products, and Compositions of Measurable functions	
1.7	Littlewood's Three Principles	
1.8	Egoroff's Theorem and Lusin's Theorem	
2	**Lebesgue Integration: 15 Hours**	**34%**

2.1	The Lebesgue Integral of a Bounded Measurable Function over a Set of Finite Measure.	
2.2	Comparison of Riemann and Lebesgue integrations.	
2.3	The Lebesgue Integral of a Nonnegative Measurable Functions,	
2.4	The General Lebesgue Integral,	
2.5	Countable Additivity and Continuity of Integration.	
2.6	Fatou's lemma and monotone convergence theorem	
2.7	General Lebesgue integral,	
2.8	Dominated convergence theorem.	
2.9	Convergence in measure.	
3	**Some classes of functions: 15 Hours**	**33%**
3.1	Continuity and Differentiability of Monotone Functions,	
3.2	Functions of Bounded Variation.	
3.3	Absolutely Continuous Functions.	
3.4	Integrating Derivatives: Differentiating Indefinite Integrals.	
3.5	Convex Functions	

C. Instructional Method and Pedagogy:

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in last lecture.
- At the end of the lecture, teacher will say the topic he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	describe and dissect many core concepts of Real Analysis and solve many integrations
CO2	apply the concepts of this course to learn some other courses of Mathematics like Functional Analysis, Banach Algebras, Harmonic Analysis etc.
CO3	apply the concepts developed in this course in several branches of engineering.
CO4	develop their academic leadership through problem solving sessions of real analysis
CO5	develop their communication skills and an academic practice through self-prepared seminars of real analysis.
CO6	develop and enhance their ability of critical and clear thinking and their planning ability through the proof of the results of real analysis.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	-	-	-	3	3	3
CO2	3	-	3	3	-	-	--	-	3	-	3
CO3	3	-	3	3	3	-	-	-	3	-	3
CO4	3	3	3	3	-	-	-	-	3	-	3
CO5	3	-	-	-	-	3	-	3	-	-	3
CO6	3	3	3	3	-	-	-		-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

H.L.Royden, Real Analysis (3rd Edition) Mc. Millan, 1998

Reference Books:

1. Rana, I. K., An introduction to measure and integration, Narosa Publ. House, New Delhi, 1997.
2. De Barra G. Introduction to measure theory, Van Nostrand Reinhold Co., 1974.

3. J. N. McDonald and N. A. Weiss; A Course on Real Analysis, Academic Press (2004)
4. Kolmogorov And S. V. Fomin; Elements Of The Theory Of Functions And Functional Analysis Volume 2 Measure. The Lebesgue Integral. Hilbert Space, GRAYLOCK PRESS ALBANY, N. Y. (1961)
5. S. Hartman And J. Mikuslnski; The Theory of Lebesgue Easure And Integration, PERGAMON PRESS

URL Links:

http://home.iitk.ac.in/~tmk/courses/mth404/main.

https://ocw.mit.edu/courses/mathematics/18-125-measure-and-integration-fall-2003/lecture-notes/

https://www.uio.no/studier/emner/matnat/math/MAT2400/v11/RealAnalCh4.pdf

http://www.math.utoronto.ca/almut/MAT1000/LL-1.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY
FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – II

MA726: PROBLEMS AND EXERCISES IN MATHEMATICS - 2

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	5	1	6	5
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Minimum number of hours
1.	Algebra	15
2.	Differential Geometry	15
3.	Linear Algebra	15
4.	Partial Differential Equations	15
5.	Real Analysis	15
	Total	**75**

B. Detailed Syllabus:

1. Problems and Exercises in Algebra **15 Hours** **20%**
2. Problems and Exercises in Differential Geometry **15 Hours** **20%**
3. Problems and Exercises in Linear Algebra **15 Hours** **20%**
4. Problems and Exercises in Partial Differential Equations **15 Hours** **20%**
5. Problems and Exercises in Real Analysis **15 Hours** **20%**

C. Instructional Method and Pedagogy:

- At the starting of course, the teacher will say to the students the importance of this course.
- In this course, emphasizes will be given to problem solving.
- At the starting of the lecture, the teacher will recall problems discussed in the last session.
- At the end of the lecture, the teacher will give some problems to be discussed in the next session.
- Teacher will solve some problems in the class.

- Students will solved problems in the class with the help of the faculty members.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	understand the theory part of courses they have studied
CO2	enhance his/her thinking which would be helpful to them who are preparing for competitive examinations.
CO3	encourage/ inspire to go for research in Mathematics
CO4	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO5	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	-	-	-	-	-	-	3
CO2	3	3	3	3	-	-	-	-	-	-	3
CO3	3	3	3	3	-	-	-	-	-	-	3
CO4	3	3	3	3	-	3	-	-	-	-	3
CO5	3	3	3	3	-	3	3	3	-	-	3
CO6	3	3	3	3	-	3	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

All books mentioned in above syllabus of semester II as text books.

Reference Books:

All books mentioned in above syllabus semester II as reference books.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY
FACULTY OF MANAGEMENT STUDIES
DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES
HS106.02 (E):: ACADEMIC WRITING

I. Credits and Schemes:

Sem.	Course Code	Course Name	Credits	Teaching Scheme	Evaluation Scheme				
				Contact Hours/Week	Theory		Practical		Total
					Internal	External	Internal	External	
II	HS106.02 (E):	ACADEMIC WRITING	02	02	--	--	30	70	100

II. Course Outline

Module No.	Title / Topic	Classroom Contact Hours
1	**Academic Writing and Research Process** • Introduction to Academic Writing • Academic Writing as a Part of Research • Types of Academic Writing • Features of Academic Writing • Importance of Good Academic Writing in various Academic Works	**05**
2	**Anatomy of Academic Writing** • Academic Vocabulary • Simple and Complex Sentences • Organizing Paragraphs • The Writing Process • Adopting Academic Writing Style	**05**
3	**Key Academic Skills** • Note – taking • Note – making • Paraphrasing • Summarizing	**05**
4	**Accuracy in Academic Writing** • Lexical Range • Academic Language and Structures • Elements of Writing • Proof Reading, Editing, and Rewriting	**05**
5	**Using and Citing Sources of Ideas** • Academic Texts and their Types • Intellectual Honesty in Academic Writing • Avoiding Plagiarism – Idea Theft • Degrees of Plagiarism	**05**

	• Types of Borrowing • Anatomy of Citations • Common Citation Styles	
6	**Contemporary Practices in Academic Writing** • Analytical Essays • Graph / Table / Process Interpretation and Description • Writing Reports • Writing Research / Concept Papers	**05**
Total		**30**

III. Instruction Methods and Pedagogy

The course is based on practical learning. Teaching will be facilitated by reading material, discussion, task-based learning, projects, assignments and various interpersonal activities like writing, group work, independent and collaborative research, etc.

IV. Evaluation

The students will be evaluated continuously in the form of their consistent performance throughout the semester. There is no theoretical evaluation. There is just practical evaluation. The evaluation (practical) is schemed as 30 marks for internal evaluation and 70 marks for external evaluation.

Internal Evaluation

The students' performance in the course will be evaluated on a continuous basis through the following components:

Sl. No.	Component	Number	Marks per incidence	Total Marks
1	Paragraph Writing	1	3	03
2	Note-taking / Note-making	1	3	03
3	Paraphrasing / Summarizing	1	4	04
4	Essay Writing	1	5	05
5	Concept Paper Writing	1	10	10
5	Attendance and Class Participation			05
			Total	**30**

External Evaluation

The University Practical Examination will be for 70 marks and will test the professional communication skills and academic writing skills of the students.

Sl. No.	Component	Number	Marks per incidence	Total Marks
1	Viva / Practical /Quiz/ Project / Academic Writing	-	70	70
			Total	**70**

Course Outcome (COs):

After completion of the course, the student would:

CO1	have sound understanding of the concept and applications of academic writing
CO2	have acquired enough knowledge of academic writing style, strategy and approach
CO3	be able to demonstrate error free and effective academic writing
CO4	be able to demonstrate ability to work on project/report/paper writing
CO5	understand the concept of plagiarism and learn to use different citation styles as a part of referencing

Course Articulation Matrix:

Correlation levels 1, 2 or 3 are as defined below:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	-	-	-	3	-	-	-
CO4	-	-	-	-	-	-	-	3	-	-	-
CO5	-	-	-	-	-	-	3	-	-	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

v. **Reference Books / Reading**

Essential Reading for Concepts

- Academic Writing for International Students, Routledge
- Academic Writing: A Guide for Management Students and Researchers. Monipally, M. M. & Pawar, B. S. Sage. 2010. New Delhi

Essential Reading for Activity and Teacher Resource

- ***Effective Academic Writing Level - 1,2,3,4 (Second Edition) By:*** Alice Savage, Patricia Mayer, Masoud Shafiei, Rhonda Liss, & Jason Davis; *Publisher: Oxford*

Additional Reading

- Writing Your Thesis (2nd Edition) by Paul Oliver, Sage
- Development Communication In Practice by Vilanilam V J, Sage
- Intercultural Communication by Mingsheng Li, Patel Fay, Sage
- www.owl.perdue.edu

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

Faculty of Science

DEPARTMENT OF MATHEMATICAL SCIENCES

Syllabus

M. Sc. (Mathematics) (Semester-III & IV)

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)								
Subjects of M.Sc.(Mathematics) Semester-3								
Course Code	Course Title	Teaching scheme (hours)				Theory Evaluation		Total
		L	P	Total hrs.	Total Credits	Internal	External	
MA811	Mathematical Methods - 1	4	0	4	4	30	70	100
MA813	Topology -2	4	0	4	4	30	70	100
MA814	Functional Analysis	4	0	4	4	30	70	100
MA824	Special Functions	4	0	4	4	30	70	100
MA835	Research Project-1	0	12	12	6	50	100	150
	Departmental Elective-1	4	0	4	4	30	70	100
	Total			**32**	**26**			**650**

Elective Courses

Course Code	Course Title	Teaching scheme (hours)				Theory Evaluation		Total
		L	P	Total hrs.	Total Credits	Internal	External	
MA817	Mathematical Foundation of Mechanics	4	0	4	4	30	70	100
MA818	Graph Theory	4	0	4	4	30	70	100
CS291	Data Analytics	4	0	4	4	30	70	100

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY (CHARUSAT)								
Subjects of M.Sc.(Mathematics) Semester-4								
Course Code	Course Title	Teaching scheme (hours)				Theory Evaluation		Total
		L	P	Total hrs.	Total Credits	Internal	External	
MA821	Mathematical Methods - 2	4	0	4	4	30	70	100
MA822	Advanced Complex Analysis	4	0	4	4	30	70	100
MA812	Algebra - 2	4	0	4	4	30	70	100
MA827	Statistical Methods and Probability Theory	4	0	4	4	30	70	100
MA855	Research Project-2	0	12	12	6	50	100	150
	Departmental Elective-2	4	0	4	4	30	70	100
	Total			**32**	**26**			**650**

Elective Courses

Course Code	Course Title	Teaching scheme (hours)				Theory Evaluation		Practical Evaluation		Total
		L	PR	Total hrs.	Total Credits	Internal	External	Internal	External	
MA819	Operations Research	4	0	4	4	30	70	---	---	100
MA828	Tribology	4	0	4	4	30	70	---	---	100
MA823	Banach Spaces and Banach Algebras	4	0	4	4	30	70	---	---	100
MA829	Computer Programming and Mathematical Algorithms	2	4	6	4	15	35	15	35	100

Internal Evaluation: Internal evaluation will be done as under:

Name of examination	Number	Examination duration	Distribution of internal of 30 marks
Internal Test	Two	60 minutes each	20
Quiz	At least two	5 to 30 minutes each	05
Viva/Assignments	At least one	About 5 to 10 minutes each (For Viva)	05

The evaluation will be done by the faculty members.

University examination:

There will be university examination at the end of each semester.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – III

MA811: MATHEMATICAL METHODS – 1

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the Course:

Sr. No.	Title of the unit	Number of hours
1.	Fourier series and applications	15
2.	Fourier transforms and applications	15
3.	Laplace transforms and applications	15
4.	Orthonormalizations and other topics	15
	Total hours:	**60**

B. Detailed Syllabus:

1.	**Fourier series and applications:**		**15 Hours**	**25%**
	1.1	Fourier series and Fourier coefficients. Parseval's identity		
	1.2	Computation of Fourier series of some functions		
	1.3	Fourier series and applications to boundary value problems Dirichlet and Neumann problems		
2	**Fourier transforms and applications:**		**15 Hours**	**25%**
	2.1	Fourier integral representation and its applications		
	2.2	Fourier transforms and its properties		
	2.3	Computations of Fourier transforms of functions		
	2.4	Convolution and Fourier transform		

	2.5	Applications to the boundary value problems involving Heat equation, Wave equation and Laplace equations	
3	**Laplace transforms and applications: 15 Hours**		**25%**
	3.1	Laplace transform and its properties	
	3.2	Laplace transforms of some functions	
	3.3	Inverse Laplace transform	
	3.4	Convolution theorem	
	3.5	Applications to solutions of ordinary differential equations, applications to the solutions of diffusion equation and wave equation	
4.	**Orthonormalizations and other topics: 15 Hours**		**25%**
	4.1	Gram-Schmidt orthonormalization	
	4.2	Legendre polynomials	
	4.3	Hermite polynomials	
	4.4	Jacobi polynomials	
	4.5	Z-transform	
	4.6	Green's function and its applications	
		Total hours 60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	derive a Fourier series of a given periodic function by evaluating Fourier coefficients
CO2	recognize the different methods of finding Laplace transforms and Fourier transforms of different functions

CO3	apply the knowledge of Laplace transform, Fourier transform and Finite Fourier transforms in finding the solutions of differential equations, initial value problems and boundary value problems.
CO4	solve boundary value problems using Green function

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	3	3	3	3	3	3
CO2	3	__	3	3	---	3	3	3	3	3	3
CO3	3	__	3	3	3	3	3	3	3	3	3
CO4	3	__	3	3	---	3	3	3	3	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

F. Recommended Study Material:

Reference Books:

1. Courant and Hilbert, Methods of Mathematical Physics Vol 1, Wiley International Publ . 1989
2. Lokenath Debnath And Dambarubhatta, Integral Transforms and Their Applications, Crc Press, Taylor & Francis Group (2015) Third Edition
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, New Delhi, 2004.
4. B. V. Limaye, Functional analysis, New Age International Publ. Ltd., New Delhi, 1996
5. L.A. Pipes, Applied Mathematics for Engineers and Physicists
6. M. D. Raisinghania, Advanced Differential Equations
7. Shankar Rao, Introduction to Partial Differential Equations
8. I. N. Sneddon; Special Functions of Mathematical Physics and Chemistry, Dover Publ. INC.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – III

MA813: TOPOLOGY - 2

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Basic concepts of Topology	15
2.	Compact Topological Spaces	15
3.	Separations	15
4.	Connectedness	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Basic concepts of Topology: 15 Hours**		**25%**
	1.1	Topological Spaces: Definition and Examples	
	1.2	Elementary concepts: Open sets, Closed sets, interior points, limit points, boundary points	
	1.3	Open bases and open subbases, Weak and strong topologies	
	1.4	First and second countable spaces. Continuous functions	
2	**Compact Topological Spaces: 15 Hours**		**25%**
	2.1	Compact Spaces	
	2.2	Locally compact spaces	
	2.3	One Point Compactification	
	2.4	Product topology and Tychonoff Theorem	
3	**Separations: 15 Hours**		**25%**

	3.1	T_0, T_1 spaces, Hausdorff spaces,		
	3.2	Completely regular spaces, normal spaces		
	3.3	Urysohn's lemma		
	3.4	Tietze Extension Theorem		
	3.5	Stone-Cech Compactification		
4.	**Connectedness:**		**15 Hours**	**25%**
	4.1	Connected and disconnected spaces		
	4.2	Components		
	4.3	Totally Disconnected Spaces		
	4.4	Locally connected Spaces		
	4.5	Locally compact Housdorff Spaces		
	4.6	Stone-Weierstrass Theorems (without proof)		
		Total	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	analyze many core concepts of General topology.
CO2	apply the concepts of this course to learn some other courses of Mathematics especially analysis.
CO3	apply these topics in the Physics and Computer engineering, Information & Technology etc.
CO4	summarize the basic concepts of generalized topology to the application point of view in Dynamical system, Homotopy, etc.

CO5	develop and enhance their ability of critical and clear thinking and their planning ability through the proof of the results of real analysis.
CO6	develop their communication skills and an academic practice through self-prepared seminars of real analysis.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	-	3	-	-	-	-	3
CO2	3	-	3	3	-	-	-	-	-	-	3
CO3	3	3	3	3	3	-	-	-	3	-	3
CO4	3	3	3	3	-	-	-	-	-	-	3
CO5	3	3	3	3	-	-	-	-	-	-	-
CO6	3	3	-	-	-	-	-	3	-	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

1. Simmons G. F., Introduction to Topology and Modern Analysis, Tata McGraw-Hill Co.
2. Munkres, J., Topology: A First Course, Prentice Hall of India Pvt. Ltd., New Delhi

Reference Books:

1. Joshi, K. D. Introduction to General Topology, Wiley Eastern Ltd. 1984
2. Willards, S., General Topology, Addison-Wesley, Reading, 1970.

URL Links:

http://home.iitk.ac.in/~chavan/topology_mth304.pdf

http://www.cmi.ac.in/~debangshu/TopNotes.pdf

http://www.math.harvard.edu/~ctm/papers/home/text/class/harvard/131/course/course.pdf

https://www3.nd.edu/~stolz/Math60330(F2014)/Notes_Pointset_Topology.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – III

MA814: FUNCTIONAL ANALYSIS

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Inner product spaces	15
2.	Approximation, optimization and standard theorems	15
3.	Bounded linear operators	15
4.	Spectrum and Numerical Range. Compact self-adjoint operators	15
	Total hours:	60

B. Detailed Syllabus:

1	**Inner product spaces:**	**15 Hours**	**25%**
	1.1	Inner product spaces: Definition and examples. Normed linear space: Definition and examples	
	1.2	Polarization identity, Schwarz's inequality	
	1.3	Orthogonal sets, Gram-Schmidt Orthonormalization, Bessel's inequality	
	1.4	Hilbert spaces. Orthonormal basis. Riesz – Fischer theorem	
	1.5	Separable Hilbert space	
	1.6	Weak convergence and weak boundedness	

2	**Approximation, optimization and standard theorems: 15 Hours**		**25%**
	2.1	Existence and uniqueness of Best approximation from a certain set to a point	
	2.2	Gram- matrix and its applications	
	2.3	Best approximation from a closed subspace to a point	
	2.4	Projection theorem	
	2.5	Riesz representation theorem	
	2.6	Unique Hahn- Banach extension theorem	
3	**Bounded linear operators: 15 Hours**		**25%**
	3.1	Continuity / boundedness of a linear operator. Adjoint of a bounded operator	
	3.2	Matrix representation of a bounded operator	
	3.3	Adjoint of a bounded operator.	
	3.4	Normal and unitary operators	
	35	Self-adjoint operators. Positive operators	
4	**Spectrum and Numerical Range. Compact self-adjoint operators. 15 Hours**		**25%**
	4.1	Definition and Example: the spectrum of a bounded operator	
	4.2	Parts of the spectrum and its relations. Results on spectrum	
	4.3	Definition of Numerical range of an operator. Relationship of the spectrum and numerical range of an operator. Results on numerical range	
	4.4	Compact operators, Hilbert - Schmidt operator	
	4.5	Compact self-adjoint operators	
	4.6	Statement of "Spectral theorem for a compact self-adjoint operator"	
		Total hours 60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.

- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	understand the Geometry on some vector spaces
CO2	apply the concepts of this course to Physics and Quantum Mechanics
CO3	apply the concepts of this course in the study Banach Algebras
CO4	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO5	through the proof of the theorems, lemmas etc. covered in this course, students will be able to develop and enhance their ability of critical and clear thinking and ability of planning
CO6	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	-	3	-	-	-	-	-	3
CO2	3	-	-	-	-	-	-	-	-	-	3
CO3	3	-	-	-	-	-	-	-	-	-	3
CO4	3	3	3	3	-	3	3	3	-	-	3
CO5	3	3	3	3	-	-	3	3	-	-	3
CO6	3	3	3	3	-	-	3	3	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

1. Limaye, B.V., Functional Analysis, New Age International Publ. Ltd., New Delhi, 1996

Reference Books:

1. Royden,H.L., Real Analysis (3rd Edition) Mc. Millan, 1998.
2. Simmons G. F., Introduction to Topology and Modern Analysis, Tata McGraw-Hill Co.

URL Links:

http://calvino.polito.it/~terzafac/Corsi/functional_analysis/pdf/chap1.pdf

https://www.math.uni-hamburg.de/home/gunesch/calc1/chapter11.pdf

http://www.pitt.edu/~hajlasz/Notatki/Functional%20Analysis2.pdf

http://web.maths.unsw.edu.au/~potapov/5605_2015/Lecture-Notes.html

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – III

MA824: SPECIAL FUNCTIONS

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Gamma and Beta functions	15
2.	Hypergeometric function	15
3.	Generalized hypergeometric function	15
4.	The Bessel function	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Gamma and Beta functions:**		**15 Hours**	**25%**
	1.1	Infinite product		
	1.2	Gamma function		
	1.3	Weierstrass definition		
	1.4	Euler product formula		
	1.5	Series for $\Gamma'(z)/\Gamma(z)$		
	1.6	Beta function		
	1.7	Factorial function.		
2.	**Hypergeometric function:**		**15 Hours**	**25%**
	2.1	Convergence of series		

	2.2	Integral representation	
	2.3	Differential equation	
	2.4	Analyticity of ${}_2F_1[z]$ and its properties	
	2.5	Contiguous functions relations	
	2.6	Simple and quadratic transformations	
	2.7	Kummer's theorem for ${}_2F_1[-1]$.	
3.	**Generalized hypergeometric function ${}_pF_q[z]$**	**15 Hours**	**25%**
	3.1	Convergence of series	
	3.2	Integral representation	
	3.3	Differential equation	
	3.4	Saalschutz's theorem	
	3.5	Whipple's theorem	
	3.6	Dixon's theorem	
	3.7	Confluent hypergeometric function (Integral representation and differential equation)	
	3.8	Kummer's first and second formula	
4.	**The Bessel function and generating functions**	**15 Hours**	**25%**
	4.1	The Bessel function $J_n(z)$ as ${}_0F_1[z]$	
	4.2	Differential equation	
	4.3	Recurrence relations and pure recurrence relation	
	4.4	Generating function	
	4.5	Bessel's integral	
	4.6	Index half an odd integer and Modified Bessel function	
	4.7	Generating functions of the form $G(2xt - t^2)$	
	4.8	Sets generated by $e^t\psi(xt)$	
	4.9	The generating functions $A(t)\exp[-xt/(1-t)]$	
		Total hours: 60	

D. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.

- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

E. Course Outcomes:

At the end of the course, the students would be able to

CO1	investigate and derive the properties of special functions along with their existence, conclude inter-relations between such functions, derive alternate representations of Special Functions in various forms and demonstrate use of Special Functions in Lie Algebra, Number theory and Physics.
CO2	develop their academic leadership through discussion in a group to solve exercises, queries of this course and develop communication skills through self-prepared seminar.
CO3	describe and analyze the generalized Hypergeometric function, the Bessel functions, the Confluent hypergeometric function, Generating Function relations along with their properties in a researched based problem.
CO4	through the proof of the exercises and problems, the students have to analyze it first and solve using the techniques of this course.
CO5	achieve the knowledge to analyse the problems using the methods of special functions, which helps in exploring the role of special functions in other areas of science and technology.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	3	3	-	-	-	3	-	-	-
CO2	3	3	-	-	-	3	3	3	-	-	3
CO3	3	-	3	3	-	-	-	-	-	-	3
CO4	3	-	3	3	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

F. Recommended Study Material:

Text book:

1. E. D. Rainville, Special Functions, Macmillan Co., New York, 1960

Reference Books:

1. G. E. Andrews, R. Askey, and Ranjan Roy, Special Functions, Cambridge University Press, 1999.
2. Z. X. Wang and D. R. Guo, Special Functions, World Scientific Publ., Singapore, 1989.
3. G. N. Watson, A treatise on the theory of Bessel functions, Cambridge University press, Cambridge, UK, 1996.

URL Links:

http://www.math.odu.edu/~jhh/ch115.PDF

http://www.math.ku.dk/~henrikp/wosfa/book-of-abstracts.pdf

http://www.math.tamu.edu/~fnarc/psfiles/special_fun.pdf

http://web.mst.edu/~lmhall/SPFNS/sfch5.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCES

DEPARTMENT OF MATHEMATICAL SCIENCES

MA835: Research Project - I

M. Sc. SEMESTER-III

Credits and Hours:

Teaching Scheme	Theory	Practical	Total	Credit
Hours/week	-	12	12	**6**
Marks	-	150	150	

Objectives:

The main objectives of the Research Project are to demonstrate the following abilities:

- Review the literature and gather background information
- Analyze the methodology (such as an theoretical or simulation) that answered the research question in the specified research article
- Develop scientific writing and oral presentation skills to prepare research proposal

Instructions and Evaluation:

1. Students have to work independently during his/her project.
2. The student first carry out a literature survey of their area of interest and shall gather the background information.
3. To prepare the periodic progress report in prescribed format and submit it to the supervisor for continuous evaluation after every two weeks.
4. The student is required to give a seminar/presentation on the project work done. The Project Evaluation Committee (Internal as well as External examiners) would conduct the viva-voce based on each criterion mentioned above.
5. The student is required to submit a written report at the end of the semester.

Project Evaluation

The evaluation of the project shall be done in continuous evaluation mode keeping the following criterion through presentation, seminar, viva-voce etc.

- Introduction and Background: an introduction of the research problem, clearly stating the hypothesis or objective of the work and motivation for the work. Background to the research work and similar work through exposition of relevant literature. This

should contain sufficient information to allow the audience to appreciate the literature survey you have made.

- Methods employed to carry out the research work (such as an experiment, simulation, theory etc.)
- Discussion of the outcomes of the specified research work: Results and their critical analysis should be mentioned, whether the results conform to expectations or otherwise and how they compare with other related work. Where appropriate evaluation of the work against the original objectives should be presented. Any problems or difficulties and the suggested solutions should be mentioned. Alternative solutions and their evaluation should also be included.
- Conclusion: concluding remarks, observations, open problems and suggestions for further work.

The different components of evaluation and the weights assigned to these components are depicted are mentioned in the following tables

Subject code	**Subject Name**	**Teaching scheme**			**Evaluation**		
MA835	**Research Project - I**	**P**	**Hours/Week**	**Credits**	**Internal**	**External (University)**	**Total**
		06	12	06	50	100	150

Examination: Internal Assessment

Criterion	**Marks**	**Credits**	**Remarks**
Periodic Progress	25	01	Evaluated by supervisors
Internal Evaluation(Seminar /Presentation/Viva)	25	01	Evaluated by Project Internal Evaluation Committee

Examination: External Assessment (University Level)

Criterion	Marks	Credits	Remarks
Submission and Project evaluation	50	02	Evaluated by Project Internal Evaluation Committee and External Examiner
Project Presentation and Viva-Voce	50	02	

Course Outcomes (COs):

At the end of the course, the learner will be able to

CO1	identify the recent trends in diverse research fields of Mathematics
CO2	develop a firm research proposal
CO3	design the appropriate strategic and ethical research plan
CO4	understand interdisciplinary nature of modern science and environmental sustainability
CO5	comprehend, write effective reports and make effective presentations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	-	-	3	-	-	-	-	3
CO2	3	3	-	3	-	-	3	3	-	-	3
CO3	-	3	3	3	-	3	3	-	-	-	3
CO4	3	-	3	-	-	3	-	-	3	3	3
CO5	-	3	-	3	-	-	3	3	-	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – III

MA817: MATHEMATICAL FOUNDATION OF MECHANICS

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Lagrangian formulation	15
2.	Euler-Lagrange equation, Hamilton's variational principle	15
3.	Hamilton's canonical equation of motion	15
4.	Canonical transformations	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Lagrangian formulation**	**15 Hours**	**25%**
	1.1	D'almbert's principle. Principle of virtual work	
	1.2	Classification of constraints	
	1.3	Lagrange's equation for holonomic systems and illustrations.	
	1.4	Lagrange's equation in velocity dependent potential and non-commutative forces	
2	**Euler-Lagrange equation, Hamilton's variational principle**	**15 Hours**	**25%**
	2.1	Variational calculus, statement of Euler's equations, Hamilton's variational principle	
	2.2	Derivation of Lagrange's equation from Hamilton's variational principle	
	2.3	Generalized momentum-mechanics in configuration space. Illustration on generalized momenta and energy function	

	2.4	General conservation theorem and illustration		
3	**Hamilton's canonical equation of motion**		**15 Hours**	**25%**
	3.1	Hamilton's canonical equations of motion using Legendre transform		
	3.2	Relation with Lagrange's equations		
	3.3	Conservation theorems		
	3.4	Variational principle approach to Hamilton's equation of motion		
	3.5	Variational principle and Hamilton's equation and examples		
4.	**Canonical transformations**		**15 Hours**	**25%**
	4.1	Canonical transformations		
	4.2	Generating functions		
	4.3	Symplectic condition		
	4.4	Infintesimal canonical transformations and examples		
	4.5	Poisson bracket formulation and illustration		
	4.6	General equation of motion and its formal solution		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcomes:

At the end of the course, the students will be able to

CO1	explain the basic mechanics and solving relevant problems mathematically in modern and classical mechanics.
CO2	justify the lifelong contribution of Lagrangian and Hamiltonian in Mechanics
CO3	analyze critically about various real life activities using modern tools and understand those complex phenomena using the concepts of classical mechanics

CO4	find the solutions of the exercises and problems, the students have to analyze it first to solve. Students will be able to develop their communication skills and academic practices through self- prepared seminars.
CO5	develop their academic leadership through discussion in a group to solve exercises and quires of the course.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	3	-	-	-	-	3	-	-
CO2	3	-	-	-	-	-	-	-	-	-	3
CO3	3	3	3	3	-	-	-	-	-	3	-
CO4	-	3	3	-	-	3	-	3	-	-	-
CO5	-	-	-	-	3	3	-	-	-	-	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Book:

1. Goldstein, H., Poole, C. and Safko, J., Classical Mechanics, (Third Edition), Pearson Education, Inc., Indian Low Price Edition, 2002.
2. Bhatia, B. V., Classical Mechanics with Introduction to Nonlinear Oscillations and Chaos, Narosa Publ. House, 1997.

URL Links:

http://www.fulviofrisone.com/attachments/article/468/Arya%20-%20Classical%20Mechanics%202nd%20ed(T).pdf

http://www.astro.caltech.edu/~golwala/ph106ab/ph106ab_notes.pdf

https://www.youtube.com/watch?v=ApUFtLCrU90

http://www.damtp.cam.ac.uk/user/tong/dynamics/clas.pdf

http://farside.ph.utexas.edu/teaching/301/301.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF TECHNOLOGY

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – III

MA818: GRAPH THEORY

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Review of basic facts about graphs	15
2.	Directed graphs	15
3.	Colouring of a graph	15
4.	Matching and covers	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Review of basic facts about graphs: 15 Hours**		**25%**
	1.1	Connected graph, tree, Euler graph, fundamental circuits	
	1.2	Matrix representation of graphs	
	1.3	Directed Graphs: definitions and examples, vertex degrees	
	1.4	Some special types of digraphs	
	1.5	Directed path and connectedness, Euler digraphs	
2	**Directed graphs: 15 Hours**		**25%**
	2.1	Trees with directed edges, spanning out-tree and spanning n-tree,	
	2.2	Fundamental circuits in digraphs	

	2.3	Incidence Matrix A and Circuit matrix B of digraphs, adjacency matrix of digraph		
	2.4	Adjacency matrix of digraph		
3	**Coloring of a graph:**		**15 Hours**	**25%**
	3.1	Chromatic number, chromatic partitioning, chromatic polynomial		
	3.2	Four-color Problem		
	3.3	Hamiltonian cycles: necessary conditions, sufficient conditions		
	3.4	Isomorphic graphs		
4.	**Matching and covers:**		**15 Hours**	**25%**
	4.1	Maximum matching		
	4.2	Hall's matching condition		
	4.3	Min-max theorems		
	4.4	Independent sets, vertex cover, edge cover		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcomes (COs):

At the end of the course, the students will be able to

CO1	Identify the real world problems and solve it using the concepts of graph theory.
CO2	Interpret different traversal methods for trees and graphs. Model problems in Computer Science using graphs and trees
CO3	Solve problems involving vertex and edge connectivity, planarity and crossing numbers
CO4	develop their communication skills and an academic practice through self-prepared seminars of complex analysis.
CO5	develop their academic leadership through problem solving sessions of complex analysis
CO6	develop and enhance their ability of critical and clear thinking and their planning ability through the proof of the results of complex analysis.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	-	-	-	-	3	-	3
CO2	3	3	3	3	-	-	-	-	3	-	3
CO3	3	3	3	3	-	-	-	-	3	-	3
CO4	3	-	-	-	-	-	-	3	-	-	3
CO5	3	-	-	-	-	3	-	-	-	-	3
CO6	3	3	3	3	-	-	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Book:

1. Narsingh Deo: Graph Theory with applications to Engineering and Computer Science. Prentice-Hall of India Pvt. Ltd., New Delhi, 1999

Reference Book:

1. John Clark and D.A. Holton: A first look at Graph Theory, Allied Publishing Ltd., 1991
2. B. W. Douglas: Introduction to Graph Theory
3. Robin J. Wilson: Introduction to Graph Theory

URL Links:

https://www.iro.umontreal.ca/~hahn/IFT3545/GTWA.pdf

https://www.tutorialspoint.com/graph_theory/graph_theory_tutorial.pdf

http://www.hamilton.ie/ollie/Downloads/Graph.pdf

http://math.tut.fi/~ruohonen/GT_English.pdf

http://www.dtic.mil/dtic/tr/fulltext/u2/705364.pdf

https://cs.bme.hu/fcs/graphtheory.pdf

http://www.personal.psu.edu/cxg286/Math485.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF TECHNOLOGY & ENGINEERING

M. Sc. (MATHEMATICS) SEMESTER – III

CS291: Data Analytics

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

F. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Introduction to Data Science	04
2.	Linear regression and types of statistical tests	14
3.	Data Preprocessing and Cleaning	10
4.	Supervised Learning	12
5.	Unsupervised Learning	12
6.	Reinforcement Learning	04
7.	Performance Metrics	04
	Total hours:	60

G. Detailed Syllabus:

1.	**Introduction to Data Science:**		**04 Hours**	**7%**
		Introduction to Data Science, significance of Data Science in today's digitally-driven world, applications of Data Science, lifecycle of Data Science, issues in Data Science		
2	**Linear regression and types of statistical tests:**		**14 Hours**	**23%**
		Descriptive statistics, Measures of Central Tendency, Simple Linear Regression, ANOVA, Logistic Regression, Multi Linear regression, Correlation, Moving Average, Random		

		Number Generation, Histogram, Sampling, Percentile Rank, t-test, chi-square, z-test		
3	**Data Pre-processing and Cleaning:**		**10 Hours**	**16%**
		Why to pre-process data?, Data cleaning: Missing Values, Noisy Data, Data Integration and transformation, Data Reduction: Data cube aggregation, Dimensionality reduction, Data Compression, Numerosity Reduction, Data Visulization		
4.	**Supervised Learning:**		**12 Hours**	**20%**
		Classification, Decision Trees, Random Forest Classifier, Naïve Bayes Classifier, Support Vector Machine, K - Nearest Neighbours, Artificial Neural Networks		
5.	**Unsupervised Learning:**		**12 Hours**	**20%**
		Clustering, K-means, Hierarchical clustering, Density based clustering, Association Rules, Dimensionality Reduction - Principal Component Analysis		
6.	**Reinforcement Learning:**		**04 Hours**	**7%**
		Q Learning, Non deterministic rewards and Actions		
7.	**Performance Metrics:**		**04 Hours**	**7%**
		Cross-Validation, Measures of Performance for Classification (Accuracy, Confusion Matrix, Precision, Recall, F1-Score), Measures of Performance for Clustering (Homogeneity, Completeness, VMeasure)		
		Total hours	60	

Course Outcomes:

CO1: Students will be able to use concepts and methods of mathematical disciplinesrelevant to data analytics and statistical modelling.

CO2: Students will demonstrate proficiency with statistical analysis of Physics data.

CO3: Student will know how to use Machine learning concepts for prediction in DataAnalytics.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	1	1	3	3	-	3	-	1	1	-	2
CO2	-	-	3	3	1	2	1	1	1	1	-
CO3	-	-	3	3	-	3	1	2	2	-	2

Text Books:

a. "Machine Learning", Tom Mitchell, McGraw Hill, 1997. ISBN 0070428077

b. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, 2004

c. Hastie, Trevor, et al., "The elements of statistical learning," Vol. 2. No. 1. New York springer, 2009.

d. Montgomery, Douglas C., and George C. Runger. "Applied statistics and probability for engineers," John Wiley & Sons, 2010.

Reference Books:

a. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.

b. Richard O. Duda, Peter E. Hart & David G. Stork, "Pattern Classification. Second Edition", Wiley & Sons, 2001.

c. Trevor Hastie, Robert Tibshirani and Jerome Friedman, "The elements of statistical learning", Springer, 2001.

d. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", MIT Press, 1998.

Web Materials:

a. https://nptel.ac.in/courses/110106072/

b. https://www.youtube.com/playlist?list=PLRueFtKLr0QN7MmQ8pdpQerOe_s8vGJG4

c. https://www.youtube.com/watch?v=PPLop4L2eGk&list=PLLssT5z_DsKh9vYZkQkYNWcItqhlRJLN 19.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA821: MATHEMATICAL METHODS – 2

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the Course:

Sr. No.	Title of the unit	Number of hours
1.	Euler's equation	15
2.	Integral equations	15
3.	Fredholm integral equations	15
4.	Bessel's, Laguerre's, Hermite, Sturm-Liouville equations	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Euler's equation:**		**15 Hours**	**25%**
	1.1	Functionals. Euler's equation		
	1.2	Other forms of Euler's equation		
	1.3	Some special forms of Euler's equation, geodesics		
	1.4	Isoperimetric problems, several dependent variables		
	1.5	Functionals involving higher order derivatives		
2	**Integral equations:**		**15 Hours**	**25%**
	2.1	Integral equations, types of integral equations		
	2.2	Conversion of differential equation into an integral equation and vice versa		
	2.3	Solution of integral equation		
	24	Integral equations of convolution type		

	2.5	Abel's integral equations, integro-differential equation		
3	**Fredholm integral equations:**		**15 Hours**	**25%**
	3.1	Compact operators and some properties of compact operators		
	3.2	Compact operators on C[a, b] and L^2[a, b]		
	3.3	Fredholm integral equations		
	3.4	Fredholm alternative theorem		
	3.5	Solutions of Fredholm integral equations for separable kernels		
4.	**Bessel's, Laguerre's, Hermite, Sturm-Liouville equations:**		**15 Hours**	**25%**
	4.1	Legendre equation		
	4.2	Laguerre equation		
	4.3	Hermite equation		
	4.4	Sturm-Liouville equations		
	4.5	Conversion of various types of differential equations into Sturm-Liouville equation, their solutions		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	elaborate what functionals are, and their appreciations
CO2	use the Euler-Lagrange equation or its first integral to find differential equations for stationary paths
CO3	solve linear Volterra and Fredholm integral equations using appropriate methods
CO4	solve the Sturm-Liouville problems

CO5	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO6	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	3	3	-	3	3	3	3	3	3
CO2	3	-	3	3	-	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	-	3	3	-	3	3	3	3	3	3
CO5	3	3	3	3	3	-	-	-	-	-	3
CO6	3	3	3	3	3	-	-	3	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Reference Books:

1. Lokenath Debnath And Dambarubhatta, Integral Transforms and Their Applications, Crc Press, Taylor & Francis Group (2015) Third Edition
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publs, 3rd Edition, Delhi.
3. A. S. Gupta, calculus of variations with applications, Prentice-Hall of India, New Delhi, 1999.
4. N. Kumar, An elementary course on variational problems in calculus, Narosa Publishing House, New Delhi, 2005
5. B. V. Limaye, Functional analysis, 2nd Edition, New Delhi, 1996.
6. S. G. Mikhlin, Integral Equations and Applications.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA822: ADVANCED COMPLEX ANALYSIS

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Cauchy's formulas	15
2.	Open Mapping theorem, Maximum modulus principle	15
3.	Compactness and Convergence in the space of Analytic functions	15
4.	Riemann mapping theorem and Factorization theorem	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Cauchy's formulas: 15 Hours**		**25%**
	1.1	Index of a closed curve	
	1.2	Different versions of Cauchy's theorem and Cauchy's integral formula	
2.	**Open Mapping theorem, Maximum modulus principle: 15 Hours**		**25%**
	2.1	Counting zeros and Open Mapping Theorem	
	2.2	Meromorphic functions, the argument principle, Rouche's theorem	
	2.3	Different versions of Maximum Modulus Theorem	
	2.4	Schwarz lemma and its application	
	2.5	Convex functions and Hadmard's theorem.	
3.	**Compactness and Convergence in the space of Analytic functions: 15 Hours**		**25%**

	3.1	C(G, Ω), the spaces of continuous functions from open subset G of C to a metric space Ω. Topology of uniform convergence on compact sets		
	3.2	Normal subset of C(G, Ω), Arzela - Ascoli theorem.		
	3.3	Space of analytic functions, Hurwitz's theorem, Montel's theorem		
	3.4	Space of meromorphic functions		
4.	**Riemann mapping theorem and Factorization theorem:**		**15 Hours**	**25%**
	4.1	Riemann mapping theorem		
	4.2	Weierstrass factorization theorem		
	4.3	Factorization of functions		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	gain the many core concepts of complex variable functions.
CO2	infer a basic knowledge of the Complex Analysis.
CO3	apply concepts of this course to signal processing and control theory and to learn some other courses of Mathematics.
CO4	develop and enhance their ability of critical and clear thinking and their planning ability through the proof of the results of real analysis.
CO5	develop their communication skills and an academic practice through self-prepared seminars of real analysis.
CO6	develop their academic leadership through problem solving sessions of real analysis.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	-	-	-	-	-	-	3
CO2	3	3	3	3	-	-	-	-	-	-	3
CO3	3	3	3	3	3	-	-	-	-	-	3
CO4	3	3	3	3	-	-	-	-	-	-	3
CO5	3	3	-	-	-	-	-	3	-	-	3
CO6	3	3	3	3	-	3	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Book:

1. J. B. Conway - Functions of one complex variable, Springer Verlag.

Reference Book:

1. W. Rudin, Real and Complex Analysis, McGraw Hill, 1967
2. J. W. Brown and R. V. Churchill; Complex Variables and Applications, McGraw-Hill Education (2009) ninth edition.

URL Links:

http://people.math.sc.edu/girardi/m7034/book/AshComplexVariablesWithHyperlinks.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA812: ALGEBRA - 2

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Ring Theory	15
2.	Euclidean Ring and Polynomial Ring	15
3.	Extension Fields	15
4.	Galois Theory	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Ring Theory: 15 Hours**		**25%**
	1.1	Definition and Examples of ring	
	1.2	Special classes of rings	
	1.3	Homomorphism	
	1.4	Ideals and quotient rings	
	1.5	Field of quotients of integral domain	
2.	**Euclidean Ring and Polynomial Ring: 15 Hours**		**25%**
	2.1	Euclidean ring	
	2.2	Euclidean ring J[i] of complex numbers with integral real and imaginary part	
	2.3	Polynomial rings over a field	
	2.4	Polynomial ring over the rational field	
	2.5	Polynomial ring over a commutative ring	

3.	**Extension Fields:**		**15 Hours**	**25%**
	3.1	Finite extension of a field		
	3.2	Algebraic elements over a field		
	3.3	Roots of polynomial over a field		
	3.4	Construction with Straight-Edge and Compass		
	3.5	Derivative of a polynomial and its roots		
	3.6	Simple extension of a field		
4.	**Galois Theory:**		**15 Hours**	**25%**
	4.1	Automorphisms on a field		
	4.2	Fixed field of Group of automorphisms on a field and examples		
	4.3	Group of automorphisms of a field K relative to a subfield F (in notation G(K, F))		
	4.4	Relationship of degree of K over F and G(K,F)		
	4.5	Normal extension of a field		
	4.5	Fundamental theorem of Galois Theory		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	understand the many core concepts of algebra and understand the Galois Theory
CO2	ready to go for higher study in Algebra
CO3	understand Theory of Equations
CO4	through the proof of the theorems, lemmas etc. covered in this course, students will be able to develop and enhance their ability of critical and clear thinking and ability of planning
CO5	develop their academic leadership through discussion in a group to solve exercises and queries of this course
CO6	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	-	-	-	-	-	-	-	-	3
CO2	3	-	-	-	-	-	-	-	-	-	3
CO3	3	-	-	-	-	-	-	-	-	-	3
CO4	3	3	3	3	-	3	3	-	-	-	3
CO5	3	3	3	3	-	3	3	-	-	-	3
CO6	3	3	3	3	-	3	3	3	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Books:

1. I. N. Herstein, Topics in Algebra, Wiley Eastern. Ltd., New Delhi, 1975.

Reference Books:

1. M. Artin,, Algebra, Prentice Hall of India, 1991.
2. P.B. Bhattacharya, SK Jain and SR Nagpaul, Basic Abstract Algebra (2/e), Cambridge University Press, South Indian Edition 2002.
3. N. Jacobson, Basic Algebra, Vol. II, Hundastan Publ. Co., Delhi, 1984.
4. I.S. Luthar and I.B.S. Passi, Algebra Vol 3: Modules, Narosa Publishing House, New Delhi, 2004

URL Links:

http://www.math.ucsd.edu/~njw/Teaching/Math271C/Lecture_18.pdf

https://wwwf.imperial.ac.uk/~anskor/notesM2P4.pdf

http://www.math.uchicago.edu/~may/VIGRE/VIGRE2009/REUPapers/Moy.pdf

https://www.math.ku.edu/~mandal/math791/spFteen791/P6Extension.pdf

http://www.math.iitb.ac.in/~srg/Lecnotes/galois.pdf

http://www.math.tifr.res.in/~publ/pamphlets/galoistheory.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA827: STATISTICAL METHODS AND PROBABILITY THEORY

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Discrete Probability Distributions	10
2.	Continuous Probability Distributions	15
3.	Parametric Estimation	15
4.	Statistical Inference	20
	Total hours:	60

B. Detailed Syllabus:

1.	**Discrete Probability Distributions: 10 Hours**		**17%**
	1.1	Discrete Random Variables	
	1.2	Expectation, Variance, Moments and Moment Generating function	
	1.3	The Binomial Distribution	
	1.4	The Negative Binomial Distribution	
	1.5	The Poisson Distribution	
2.	**Continuous Probability Distributions: 15 Hours**		**25%**
	2.1	Continuous Random Variables	
	2.2	The Exponential, Gamma and Chi-Square Distributions	
	2.3	The Normal Distribution	
	2.4	Vector Random Variables and Distribution of Functions of Vector Random Variables	

	2.5	Independent Random Variables	
	2.6	Dispersion matrix and correlations Covariance, Correlation, and Moments	
3.	**Parametric Estimation: 15 Hours**		**25%**
	3.1	Sampling and Sampling Distributions	
	3.2	Law of Large Numbers and Central Limit Theorem	
	3.3	Problem of Point Estimation: Unbiased Estimation, Maximum Likelihood Estimation	
	3.4	Interval Estimation: Confidence Intervals based on Sampling from Normal Distribution: Mean, Variance, Proportion, Difference in mean	
4.	**Statistical Inference: 20 Hours**		**33%**
	4.1	Introduction to Hypothesis: Simple and Composite Hypotheses	
	4.2	Types of Errors in Tests of Hypotheses, Power of a Statistical Test	
	4.3	Hypotheses Tests based on Sampling from Normal Distributions: Mean, Variance, Several Means, Several Variances	
	4.4	Categorical Data: Association and Independence	
	4.2	Test of Independence of Attributes	
		Total hours 60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcomes:

At the end of this course, student will be able to

CO1	interpret and apply probability techniques in problem solving.
CO2	define random variables and its probability distribution and determine transformation of random variables.
CO3	compute the moments (mean and variance) and the moment generating function of random variable
CO4	understand the important properties of known probability distributions (Binomial, Poisson, Normal, t, χ^2 and F distributions), and use of central limit theorem, apply tests of hypotheses in different areas of science.
CO5	solve the problems of competitive examinations like UGC-NET (Mathematical Sciences),GATE related to probability and statistics
CO6	develop their communication skills through self-prepared seminar, illustrate, and explain ideas contained in data analysis problems.

Course articulation matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	3	3	3	-	-	-	-	-	-
CO2	3	-	3	3	3	-	-	-	-	-	-
CO3	3	-	3	3	3	-	-	-	-	-	-
CO4	3	-	3	3	3	-	-	-	-	-	-
CO5	3	3	3	3	3	-	-	-	-	-	3
CO6	3	3	-	-	-	3	3	3	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text-Books

1. Robert Hogg, Elliot Tanis, Probability and Statistical Inference,2009.
2. Mood and Graybill, Introduction to the theory of Statistics,Mc-GrawHill, 1974.
3. Goon A. M. , Gupta M K and Dasgupta B., Fundamentals of Statistics Vol 1, 2002.

Reference Books

1. Vijay K Rohatgi and AK Md Ehsanes Saleh, Probability and Statistics. John Wiley & Sons, 2001.
2. George G. Roussas, An Introduction to Probability and Statistical Inference. Academic Press,2003.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCES

DEPARTMENT OF MATHEMATICAL SCIENCES

MA855: Research Project - II

M. Sc. SEMESTER-IV

Credits and Hours:

Teaching Scheme	Theory	Practical	Total	Credit
Hours/week	-	12	12	**6**
Marks	-	150	150	

Objectives:

The main objectives of the Research Project - II are to demonstrate the following abilities:

- Analyze the methodology (such as an theoretical or simulation) that answered the research question in the specified research article
- Develop scientific writing and oral presentation skills to prepare research proposal

Instructions and Evaluation:

1. Students have to work independently during his/her project.
2. The student first carry out a literature survey of their area of interest and shall gather the background information.
3. To prepare the periodic progress report in prescribed format and submit it to the supervisor for continuous evaluation after every two weeks.
4. The student is required to give a seminar/presentation on the project work done. The Project Evaluation Committee (Internal as well as External examiners) would conduct the viva-voce based on each criterion mentioned above.
5. The student is required to submit a written report at the end of the semester.

Project Evaluation

The evaluation of the project shall be done in continuous evaluation mode keeping the following criterion through presentation, seminar, viva-voce etc.

- Methods employed to carry out the research work (such as an experiment, simulation, theory etc.)

- Discussion of the outcomes of the specified research work: Results and their critical analysis should be mentioned, whether the results conform to expectations or otherwise and how they compare with other related work. Where appropriate evaluation of the work against the original objectives should be presented. Any problems or difficulties and the suggested solutions should be mentioned. Alternative solutions and their evaluation should also be included.
- Conclusion: concluding remarks and observations, unsolved problems, suggestions for further work.

The different components of evaluation and the weights assigned to these components are depicted are mentioned in the following tables

Subject code	**Subject Name**	**Teaching scheme**			**Evaluation**		
MA855	**Research Project - II**	**P**	**Hours/Week**	**Credits**	**Internal**	**External (University)**	**Total**
		06	12	06	50	100	150

Examination: Internal Assessment

Criterion	**Marks**	**Credits**	**Remarks**
Periodic Progress	25	01	Evaluated by supervisors
Internal Evaluation(Seminar /Presentation/Viva)	25	01	Evaluated by Project Internal Evaluation Committee

Examination: External Assessment (University Level)

Criterion	**Marks**	**Credits**	**Remarks**
Submission and Project evaluation	50	02	Evaluated by Project Internal Evaluation Committee and External Examiner
Project Presentation and Viva-Voce	50	02	

Course Outcomes (COs):

At the end of the course, the learner will be able to

CO1	identify the recent trends in diverse research fields of Mathematics
CO2	develop a firm research proposal
CO3	design the appropriate strategic and ethical research plan
CO4	understand interdisciplinary nature of modern science and environmental sustainability
CO5	comprehend, write effective reports and make effective presentations
CO6	cultivate leadership qualities to implement a workflow to fulfill tasks

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	-	-	3	-	-	-	-	3
CO2	3	3	-	3	-	-	3	3	-	-	3
CO3	-	3	3	3	-	3	3	-	-	-	3
CO4	3	-	3	-	-	3	-	-	3	3	3
CO5	-	3	-	3	-	-	3	3	-	-	3
CO6	3	3	3	3	3	-	3	3	3	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA819: OPERATIONS RESEARCH

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Introduction	15
2.	Special Cases of Simplex Method, Duality	15
3.	Transportation Model	15
4.	Network Models	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Introduction:**	**15 Hours**	**25%**
	1.1	Introduction to linear programming	
	1.2	Modeling with linear programming	
	1.3	Graphical Solutions	
	1.4	LP model in equation form	
	1.5	Simplex Method	
	1.6	Basic solutions	
	1.7	Artificial starting solution	
	1.8	Sensitivity Analysis	
2.	**Special Cases of Simplex Method, Duality:**	**15 Hours**	**25%**

	2.1	Degeneracy		
	2.2	Alternative optima		
	2.3	Duality definition and Dual problem		
	2.4	Economic interpretation and duality		
	2.5	Dual Simplex Method		
3	**Transportation Model:**		**15 Hours**	**25%**
	3.1	Transportation Models		
	3.2	Nontraditional Transportation Models		
	3.3	Assignment Model		
	3.4	Transportation models, Assignment models and applications		
4.	**Network Models:**		**15 Hours**	**25%**
	4.1	Scope and Definition		
	4.2	Shortest – Route Problem		
	4.3	Maximal Flow Model		
	4.4	Critical Path Model		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcomes (COs)

At the end of the course, the students would be able to

CO1	Examine types of solutions in optimization problems and formulate Linear Programming Problem
CO2	Define duality in linear programming problem and construct dual linear programming problem

CO3	Solve the linear programming problems using various methods.
CO4	Formulate Transportation problem, Assignment problem and solve them
CO5	Identify network models and classify the optimization problems
CO6	Apply different algorithms and solve the related network models

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	-	-	3	-	-	3
CO2	3	-	3	3	3	-	-	3	-	-	3
CO3	3	-	3	3	3	-	-	3	-	-	3
CO4	3	-	3	3	3	-	-	3	-	-	3
CO5	3	-	3	3	3	-	-	3	-	-	3
CO6	3	3	3	3	3	-	-	3	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Book:

1. Hamdy A. Taha: Operations Research, an introduction , Prentice-Hall, 2007

Reference Book:

1. G. Hadley, Linear Programming, Addition Wesley Publ (1962)
2. Frederick S. Hillier And Gerald J. Lieberman, Introduction To Operations Research Mcgraw-Hill Higher Education 2001

URL Links:

http://lipas.uwasa.fi/~tsottine/lecture_notes/or.pdf

https://www.doc.ic.ac.uk/~br/berc/linearprog.pdf

http://www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf

http://web.itu.edu.tr/topcuil/ya/OR.pdf

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA828: TRIBOLOGY

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Introduction to Tribology	15
2.	Basic equations in Tribology	15
3.	Fluid Film Lubrication	15
4.	Introduction to bearings	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Introduction to Tribology:**	**15 Hours**	**25%**
	1.1	Historical background, Tribological surfaces	
	1.2	Friction and wear	
	1.3	Effect of lubrication	
	1.4	Bearing selection	
	1.5	Applications of Tribology	
2.	**Basic equations in Tribology:**	**15 Hours**	**25%**
	2.1	Kinematics, Velocity, acceleration	
	2.2	The transport theory	
	2.3	Equation of continuity	
	2.4	Stress, equation of motion	

	2.5	The Navies-Stokes equation		
	2.6	Reynolds equation		
3.	**Fluid Film Lubrication:**		**15 Hours**	**25%**
	3.1	Introduction to thick film lubrication		
	3.2	Lubrication regimes, Turbulence		
	3.3	Elastohydrodynamic lubrication		
	3.4	Gas lubrication, thermal effects		
	3.5	Lubrication with non-Newtonian fluids		
4.	**Introduction to bearings:**		**15 Hours**	**25%**
	4.1	Hydrodynamics bearings		
	4.2	squeeze film bearing		
	4.3	One dimensional bearings		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcomes (COs):

At the end of the course, students would able to

CO1	describe many core concepts about the basics of tribology in modern sciences through tribological process.
CO2	apply the methods to reduce the friction and wear using mathematical approach of hydrodynamic and hydrostatic lubrication for engineering surface with the help of complex problem solving techniques.
CO3	apply the concepts developed in this course in several branches of engineering.

CO4	develop their communication skills and an academic practice through self-prepared seminars of Tribology.
CO5	develop their academic leadership through problem solving sessions of Tribology.
CO6	develop and enhance their ability of critical and clear thinking and their planning ability through the understanding of the results of Tribology.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	-	3	-	-	3	3	3
CO2	3	-	3	3	-	-	-	-	3	3	3
CO3	3	-	3	3	3	-	-	-	3	-	3
CO4	3	-	-	-	-	-	-	3	-	-	3
CO5	3	-	-	-	-	3	-	-	-	-	3
CO6	3	3	3	3	-	-	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Book:

1. B. Bhushan, Principles and Application of Tribology, Wiley, 2013.
2. B C Majumdar, Introduction to Tribology, S Chand and Co., 2008.

Basic Text & Reference Books:-

1. S. K. Basu, S. N. Sengupta and B. B. Ahuja, Fundamentals of Tribology, , PHI, 2010
2. Cameron, Basic Lubrication Theory, John Wiley and Sons, 1971
3. Andras Z. Szeri, Fluid film lubrication, Cambridge University Press, second edition, 2011.

URL Links:

http://nptel.ac.in/courses/112102015/

https://en.wikipedia.org/wiki/Tribology

http://nptel.ac.in/courses/112102015/17

http://www.tribonet.org/wiki/

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA829-COMPUTER PROGRAMMING AND MATHEMATICAL ALGORITHMS

Credits and Hours

Teaching Scheme	Theory	Practical	Total	Credit
Hours/week	2	4	6	4
Marks	50	50	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Basics of C programming	15
2.	Functions, Files and Structure	15
3.	Programme to be performed on Computers	30
4.	Programme to be performed on Computers	30
	Total hours:	90

B. Detailed Syllabus:

1.	**Basics of C programming:**	**15 Hours**	**25%**
	1.1	Structure of a C program; The concept of function. Constants, Variables in C, integer family; float family; character family, define statement. Data types and declaration of variables. Preprocessors in C; include statement; function prototype error	
	1.2	Arithmetic and relational operators in C. Precedence and associativity of operators; standard library functions. Arithmetic expressions; logical expressions	
	1.3	input – output functions; I/O format string; precision of numbers; field width	
	1.4	Control statements: if, if-else; switch statement. Loops : while, do–while, for; break and continue statements;	
	1.5	Pointers – address of a variable, pointer variable, pointers and array	
2.	**Functions, Files and Structure:**	**15 Hours**	**25%**

	2.1	Function definition, automatic, static and external variables. calling a function; recursive functions; function prototype – forward reference; pointers in functions; passing by values and passing by reference	
	2.2	File management: opening a file; closing a file; reading from a file; fscanf() and fprintf() functions writing to a file	
	2.3	Structures: declaration of structures, accessing structure members; structure initialization, nested structure, array of structures; structure assignment, structure as function arguments	
3.	**Programme to be performed on Computers: 30 Hours**		**25%**
	3.1	Elementary problems of number theory: sum of digits of a number reverse order of digits of a number, primes, perfect, Fibonacci numbers, factorization of a number	
	3.2	Roots of quadratic equation, maximum/minimum and average of n– numbers	
	3.3	Values of some number theoretic functions; values of sin(x), cos(x), e^x. Solution of f(x) = 0, by using numerical methods	
4.	**Programme to be performed on Computers: 30 Hours**		**25%**
	4.1	Sorting of a sequence	
	4.2	Operations on matrices, Gauss elimination method and its applications.	
	4.3	Newton's form of polynomial, interpolation polynomial, divided difference table	
	4.4	Numerical integration, numerical solutions of differential equations	
		Total hours | 90	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	write computer programs for some of Mathematical Problems
CO2	apply their knowledge of programming language to solve some of real life problems
CO3	develop their academic leadership through discussion in a group to solve exercises and queries of this course

CO4	through the writing of programs, students will be able to develop and enhance their ability of critical and clear thinking and ability of planning
CO5	find the solutions of the problems, the students have to analyse it first to solve it, develop algorithm and then write a code

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	3	-	-	-	-	-	3
CO2	3	3	3	3	3	-	-	-	-	-	3
CO3	3	-	3	3	3	3	-	-	-	-	3
CO4	3	3	3	3	3	-	-	-	-	-	3
CO5	3	-	3	3	3	-	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Reference Books:-

1. P. B. Mahapatra, Thinking in C Including object orientated programming with C++, Wheeler Publishing, New Delhi
2. B. W. Kernighan and D. M. Ritchie, The C programming Language, Prentice Hall of India Pvt. Ltd. 1990.
3. V. Rajaraman, Computer Programming in C, Prentice Hall of India Pvt. Ltd. 1995.

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICAL SCIENCES

M. Sc. (MATHEMATICS) SEMESTER – IV

MA823: BANACH SPACES AND BANACH ALGEBRAS

Credits and Hours:

Teaching Scheme	Theory	Seminar	Total	Credit
Hours/week	4	-	4	4
Marks	100	-	100	

A. Outline of the course:

Sr. No.	Title of the unit	Number of hours
1.	Normed Linear Spaces and operators	15
2.	Hahn Banach, Open mapping, closed graph and uniform boundedness theorems	15
3.	Basics of Banach Algebras	15
4.	Commutative Banach Algebras	15
	Total hours:	60

B. Detailed Syllabus:

1.	**Normed Linear Spaces and operators: 15 Hours**		**25%**
	1.1	Normed linear spaces and Banach Spaces (examples and basic properties)	
	1.2	Bounded linear transformations	
	1.3	Space of bounded linear transformations	
	1.4	Dual and second dual of a normed space, Weak and weak* convergence	
2	**Hahn Banach, Open mapping, closed graph and uniform boundedness theorems: 15 Hours**		**25%**
	2.1	Hahn-Banach extension theorem	
	2.2	Open mapping, Closed Graph and Bounded Inverse theorems	
	2.3	Uniform boundedness principle	
	2.4	Conjugate of an operator	

3	**Basics of Banach Algebras:**		**15 Hours**	**25%**
	3.1	Banach algebras, examples		
	3.2	Regular and singular elements, topological divisors of zero		
	3.3	Spectrum of an element and spectral radius, Gel'fand Mazur types theorems		
	3.4	Radical and Semi-simplicity		
4.	**Commutative Banach Algebras:**		**15 Hours**	**25%**
	4.1	The Gel'fand space, Gel'fand transform		
	4.2	Complex homomorphisms and maximal ideals		
	4.3	Applications of the Spectral Radius Formula		
	4.4	Involution in Banach algebras		
	4.5	Gelfand – Neumark theorem		
		Total hours	60	

C. Instructional Method and Pedagogy:

- At the starting of the course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of classical writing board or multi-media projector or OHP etc.
- At the starting of the lecture, teacher will recall what he/she covered in the last lecture.
- At the end of the lecture, teacher will summarize the topics covered in the lecture and inform the students about the topics he/she planned to cover in the next lecture.

D. Course Outcome (COs):

At the end of the course, the students will be able to

CO1	understand the many core concepts of Normed spaces, Banach spaces
CO2	understand the many core concepts of Banach algebras and Gelfand Theory
CO3	realize how to put extra efforts to prove the results which they have studied in Hilbert space theory in the absence of geometry.
CO4	through the proof of the theorems, lemmas etc. covered in this course, students will be able to develop and enhance their ability of critical and clear thinking and ability of planning

CO5	find the solutions of the exercises and problems, the students have to analyse it first to solve. Student will be able to develop their communication skill and academic practices through self-prepared seminars
CO6	develop their academic leadership through discussion in a group to solve exercises and queries of this course

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	-	-	-	-	-	-	-	3
CO2	3	-	-	-	-	-	-	-	-	-	3
CO3	3	-	-	-	-	-	-	-	-	-	3
CO4	3	3	3	3	-	3	3	-	-	-	3
CO5	3	3	3	3	-	3	3	3	-	-	3
CO6	3	3	3	3	-	3	3	-	-	-	3

Enter correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put "-"

E. Recommended Study Material:

Text Book:

1. G. F. Simmons, Introduction to Modern Analysis, McGraw-Hill Book Company, Inc. 1963

Reference Book:

1. B. V. Limaye, Functional Analysis, New Age International (P) Ltd., 2001
2. R. Larsen, Banach Algebras, Marcell-Dekker, 197
3. V. K. Krishnan, Text book of Functional Analysis; A problem oriented approach, Prentice Hall of India, 2001.
4. S. Ponnusamy, Foundations of Functional Analysis, Narosa Pub. House, 2004
5. Thamban Nair, Functional Analysis-a first course, Printice Hall of India, 2002.
6. E. Kaniuth, A Course in Commutative Banach Algebras, Springer, New York, 2009.

URL Links:

http://www.maths.lancs.ac.uk/~belton/www/notes/fa_notes.pdf

http://home.iitk.ac.in/~chavan/fa_mth405_1.pdf

https://people.math.ethz.ch/~salamon/PREPRINTS/funcana.pdf

http://bass.math.uconn.edu/fa090614.pdf

http://personal.lse.ac.uk/sasane/ma412.pdf

https://www.iith.ac.in/~rameshg/banachalgebras.pdf

http://www.math.nagoya-u.ac.jp/~richard/teaching/s2014/Course_Wilde.pdf

https://math.berkeley.edu/~ceur/notes_pdf/Eur_Math206_BanachSpectral_Notes.pdf

https://people.math.osu.edu/costin.9/7212/C2.pdf