PANJAB UNIVER SITY, CHANDIGARH-160014(IN DIA)

(Estd. under the Panjab University Act VII of 1947—enacted by the Govt. of India)

FA CULTY OF SCIENCE

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SYLLABI

FOR

M.Sc. MATHEMATICS (SEMESTER SYSTEM) EXAMINATION, 2020-21

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APPLICABILITY OF REGULATIONS FOR THE TIME BEING IN FORCE

Notwithstanding the integrated nature of a course spread over more than one academic year, the regulations in force at the time a student joins a course shall hold good only for the examinations held during or at the end of the academic year. Nothing in these regulations shall be deemed to debar the University from amending the regulations subsequently and the amended regulations, if any, shall apply to all students whether old or new.

GUIDELINES FOR CONTINUOUS INTERNAL ASSESSMENT (20%) FOR REGULAR STUDENTS OF POST GRADUATE COURSES of M. Sc. Mathematics (Semester System)

(Effective from the First Year Admissions for the Academic Session 2007-08)

1. The Syndicate has approved the following Guidelines, Mode of Testing and Evaluation including Continuous Internal Assessment of students:

(i)	Terminal Evaluation	80%
(ii)	Continuous Assessment	20%

(iii) Continuous Assessment may include written assignment, snap tests, participation in discussions in the class, term papers, attendance etc.

(iv) In order to incorporate an element of Continuous Internal Assessment of students, the Colleges/Departments will conduct one written test and one snap test as quantified below:

(a)	Written Test	:	25 (reduced to 5)
(b)	Snap Test	:	25 (reduced to 5)
(c)	Participation in Class Discussion	:	15 (reduced to 3)
(d)	Term Paper	:	25 (reduced to 5)
(e)	Attendance	:	10 (reduced to 2)
		Total:	**100 reduced to 20**

2. Weightage of 2 marks for attendance component out of 20 marks for Continuous Assessment shall be available only to those students who attend 75% and more of classroom lectures /seminars/ workshops.

The break-up of marks for **attendance component** for theory papers shall be as under:

Attendance Component		*Mark/s for Theory Papers*
(a) 75% and above up to 85%	:	1
(b) Above 85%	:	2

3. It shall not be **compulsory** to pass in Continuous Internal Assessment. Thus, whatever marks are secured by a student out of 20% marks, will be carried forward and added to his/her score out of 80% i.e. the remaining marks allocated to the particular subject and, thus, he/she shall have to secure pass marks both in the University examinations as well as total of Internal Continuous Assessment and University examinations.

4. Continuous Internal Assessment awards from the affiliated Colleges/Departments must be sent to the Controller of Examinations, by name, **two weeks before** the commencement of the particular examination on the proforma obtainable from the Examination Branch.

SPECIAL NOTE :

(i) The theory question paper will be out of 80 marks and 20 marks will be for internal assessment.

(ii) In the case of Postgraduate Course in the Faculties of Arts, Science, Languages, Education, Design & Fine Arts, and Business Management & Commerce (falling under the purview of Academic Council), where such a provision of Internal Assessment/Continuous Assessment already exists, the same will continue as before.

PANJAB UNIVERSITY, CHANDIGARH

OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR M.Sc. MATHEMATICS (Semester System)

Outlines of Tests

Note : Teaching hours for each paper of M.Sc. Mathematics Semester 1st to 4th be 6 hrs. per week.

M.Sc. (Pass Course) in Mathematics

SEMESTER I		**(November/December, 2020)**
MATH-601S	:	Real Analysis-I
MATH-602S	:	Algebra -I
MATH-603S	:	Differential Equations
MATH-604S	:	Complex Analysis-I
MATH-605S	:	Number Theory-I
SEMESTER II		**(April/May, 2021)**
MATH-621S	:	Real Analysis-II
MATH-622S	:	Algebra -II
MATH-623S	:	Vector Analysis and Mechanics
MATH-624S	:	Complex Analysis-II
MATH-625S	:	Number Theory–II
SEMESTER III		**(November/December, 2020)**
MATH-617S	:	Field Theory (Compulsory Course)
MATH-618S	:	Topology (Compulsory Course)
MATH-661S	:	Probability and Mathematical Statistics-I
MATH-672S	:	Computational Techniques-I
MATH-673S	:	Differential Geometry-I
MATH-674S	:	Elasticity -I
MATH-675S	:	Special Functions
MATH-676S	:	Fluid Mechanics-I
MATH-678S	:	Linear Programming

SEMESTER IV **(April/May, 2021)**

MATH-637S	:	Linear Algebra (Compulsory Course)
MATH-638S	:	Functional Analysis (Compulsory Course)
MATH-681S	:	Probability and Mathematical Statistics-II
MATH-692S	:	Computational Techniques-II
MATH-693S	:	Differential Geometry-II
MATH-694S	:	Elasticity -II
MATH-695S	:	Integral Transforms and Their Applications
MATH-696S	:	Fluid Mechanics-II
MATH-698S	:	Non-Linear Programming

SEMESTER-I

MATH 601S : Real Analysis-I

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No. 1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

(i) **Basic Topology :** Finite, countable and uncountable sets. Metric spaces, compact sets. Perfect sets. Connected sets.

(ii) **Sequences and series :** Convergent sequences (in metric spaces). Subsequences. Cauchy sequences. Upper and lower limits of a sequence of real numbers. Riemann's Theorem on Rearrangements of series of real and complex numbers.

(iii) **Continuity :** Limits of functions (in metric spaces). Continuous functions. Continuity and compactness. Continuity and connectedness. Monotonic functions.

UNIT- II

(iv) **The Riemann-Stieltjes integral**: Definition and existence of the Riemann-Stieltjes integral. Properties of the integral. Integration of vector-valued functions. Rectifiable curves.

(v) **Sequences and series of functions**: Problem of interchange of limit processes for sequences of functions. Uniform convergence. Uniform convergence and continuity. Uniform convergence and integration. Uniform convergence and differentiation. Equicontinuous families of functions, The Stone-Weierstrass theorem.

Scope

As in relevant sections of Chapters 2,3,4,6,7 of the book at Sr. No. 6 in the list of references.

References:

1. Apostol, Tom, Mathematical Analysis - A Modern Approach to Advanced Calculus, Addison - Wesley Publishing Company, Inc. 1987. (Indian Edition by Narosa Publishing House New Delhi also available).

2. Bromwich, T.J.I.A., An Introduction to the Theory of Infinite Series. Second edition (Revised with the assistance of T. M. Mac Robert). Macmillan and Co. Ltd., New York, 1955.

3. Goldberg, R.R., Methods of Real Analysis, Oxford and IHB Publishing Company, New Delhi.

4. Knopp, K., Theory and Applications of Infinite Series, Blackie and Sons Ltd. London and Glasgow Second Edition, 1951 (Reprinted 1957).

5. Malik, S.C., Mathematical Analysis, Wiley Eastern, New Delhi, 1984.

6. Rudin, Walter, Principles of Mathematical Analysis, Third Edition (International Student Edition) McGraw-Hill Inc., 1983.

7. Shanti Narayan, A Course of Mathematical Analysis, S. Chand and Co. Ltd., New Delhi, Twelfth Revised Edition, 1986.

8. Titchmarsh, E.C., The Theory of Functions, Second Edition, The English Language Book Society and Oxford University Press, 1961.

Math 602S: Algebra- I

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note : 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT- I

Review of basic concepts of groups with emphasis on exercises. Permutation groups, Even and odd permutations, Conjugacy classes of permutations, Alternating groups, Simplicity of An, $n > 4$. Cayley's Theorem, Direct products, Fundamental Theorem for finite abelian groups, Sylow theorems and their applications, Finite Simple groups [Scope as in chapters 2-4 Modern Algebra by Surjeet Singh and Qazi Zameerudin, Eighth Edition and chapters 11, 24, 25 of Contemporary Abstract Algebra by Gallian, Fourth Edition]

UNIT-II

Survey of some finite groups, Groups of order p^2, pq (p and q primes). Solvable groups, Normal and subnormal series, composition series, the theorems of Schreier and Jordan Holder [Scope as in Chapters 6 of Modern Algebra by Surjeet Singh and Qazi Zameerudin, Eighth Edition and Chapter 7 of Algebra, Vol. I by Luther and Passi].

Review of basic concepts of rings with emphasis on exercises. Polynomial rings, formal power series rings, matrix rings, the ring of Guassian Integers. [Scope as in Chapters 7, 8 and 9 of Modern Algebra by Surjeet Singh and Qazi Zameerudin, Eighth Edition , 2006].

References:

1. Luther I.S. and Passi I.B.S., *Algebra*, Vol.I & II, Narosa Publishing House, New Delhi.
2. Gallian J.A, *Contemporary Abstract Algebra,* Narosa Publishing House, New Delhi.
3. Singh Surjeet and Qazi Zameeruddin, *Modern Algebra,* Vikas Publishing House, New Delhi (8^{th} Edition) 2006.
4. Herstein I.N., *Topics in Algebra* (Second Edition), Wiley Eastern Limited, New Delhi.
5. Musili C, *Rings and Modules* (Second Revised Edition), Narosa Publishing House, New Delhi, 1994.
6. Artin M, *Algebra*, Prentice Hall of India, New Delhi, 1994.
7. Bhattacharya P.B.; Jain S.K.; and Nagpal S.R., *Basic Abstract Algebra,* Cambridge University Press, New Delhi.
8. Burnside W, *The Theory of Groups of Finite Order (2^{nd} Ed.),* Dover, New York, 1955.
9. Fraleigh J.B., *A First Course in Abstract Algebra,* Narosa Publishing House, New Delhi.
10. Hartley B. and Hawkes T.O., *Rings, Modules and Linear Algebra,* Chapman and Hall.
11. Hungerford T.W., *Algebra,* Springer 1974.

Math 603S: Differential Equations

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:
1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Differential Equations

Existence and uniqueness of solution of first order equations. Boundary value problems and Strum-Liouville theory. ODE in more than 2-variables.

[Scope as in Chapter V of the book 'An introduction to Ordinary Differential Equations' by E.A.Coddington and Chapters X & XI of the book 'Elementary Differential Equations and Boundary Value Problems' by W.E.Boyce and R.C.Diprima.]

UNIT-II

Partial differential equations of first order. Partial differential equations of higher order with constant co-efficients. Partial differential equations of second order and their classification.

[Scope as in Chapters I, II & III of the book 'Elements of Partial Differential Equations' by I.N.Sneddon].

References:

1. Coddington E.A., An Introduction to Ordinary Differential Equations. Ch. V., Prentice Hall of India Pvt. Ltd., New Delhi 1987.

2. Boyce W.E and Diprima, R.C., Elementary Differential Equations and Boundary Value Problems. Ch. X, XI, 4th Edition, John Wiley and Sons, USA.

3. Sneddon I.N : Elements of Partial Differential Equations, Ch. I, II, III, McGraw Hill, 1957.

4. Tyn Mying-U : Differential Equations of Mathematical Physics.

Math 604S : Complex Analysis-I

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Complex plane, geometric representation of complex numbers, joint equation of circle and straight line, stereographic projection and the spherical representation of the extended complex plane. Topology on the complex plane, connected and simply connected sets. Complex valued functions and their continuity. Curves, connectivity through polygonal lines.Analytic functions, Cauchy-Riemann equations, Harmonic functions and Harmonic conjugates.Power series, exponential and trigonometric functions, arg z, log z, a^z and their continuous branches.

(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 1, (§1.1-§ 1.5),Chapter 2 (§ 2.2, §2.3), Chapter 3, (§3.1-§3.5), Chapter 4, (§4.9).)

UNIT-II

Complex Integration, line integral, Cauchy's theorem for a rectangle, Cauchy's theorem in a disc, index of a point with respect to a closed curve, Cauchy's integral formula, Higher derivatives, Morrera's theorem, Liouville's theorem, fundamental theorem of Algebra. The general form of Cauchy's theorem.

(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 4, (§4.1-§ 4.8), Chapter 6 (§ 6.4, §6.6)."Complex Analysis" by L/ V. Ahlfors, Chapter 4 (§1, 2, 4.1 to 4.5and §5.1)

References:

1. Shanti Narayan, Theory of Functions of a Complex Variable, S. Chand and Co. (Seventh Edition, 1986).

2. Ahlfors, L.V., Complex Analysis, Third Edition (International student edition) McGraw-Hill International Book Company.

3. Conway, J.B., Function of One Complex Variable, Second Edition, 1978. Corr 4th Print 1986 Graduate Texts, Springer-Verlag, Indian edition by Narosa Publishing House, New Delhi.

4. Copson, E. T., An Introduction to the Theory of Functions of a Complex Variable, The English Language Book Society and Oxford University Press, 1985.

5. Knopp, K., Theory of Functions (Translated by F. Bagemite) in Two Volumes, Dover Publications, Inc. New York, 1945, 1947.

6. Pati, T., Functions of a Complex Variable, Allahabad, Pothishala, 1971.

7. Saks, S and Zygmund, A., Analytic Functions (Translated by E. J. Scott) Poland, Warszawa. 1952.

8. Silverman, R., Introductory Complex Analysis, Prentice-Hall Inc. Englewood Cliffs, N. J., 1967.

9. Deshpande, J. V., Complex Analysis, Tata McGraw-Hill Publishing Company Ltd., 1989.

10. Tichmarsh, E.C., The Theory of Functions, The English Language Book Society and Oxford University Press, Second Edition, 1961.

11. Tutschke Wolfgang and Vasudeva, Harkrishan L., An Introduction to Complex Analysis, Classical and Modern Approaches, Chapman and Hall/CRC, 2005.

12. Ponnusamy S., Foundations of Complex Analysis, Second Edition Narosa Publishing House, New Delhi, 2005

MATH-605S : Number Theory-1

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Divisibility, Greatest common divisor, Euclidean Algorithm, The Fundamental Theorem of arithmetic, congruences, Special divisibility tests, Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, residue classes and reduced residue classes, Euler's theorem, An Application to cryptography, Arithmetic functions φ (n), d(n), σ(n), μ(n), Mobius inversion Formula, the greatest integer function, perfect numbers, Mersenne primes and Fermat numbers.

UNIT-II

Primitive roots and indices. Quadratic residues, Legendre symbol, Quadratic reciprocity law, Jacobi symbol, Binary quadratic forms and their reduction, sums of two and four squares, positive definite binary quadratic forms, Diophantine equations $ax + by = c$, $x^2+y^2=z^2$, $x^4+y^4=z^2$.

[Scope as in Chapters 2-8, 10 of 'Elementary Number Theory', 2nd Edition, by David M. Burton, Chapters 3, 5(sections 5.1, 5.3, 5.4) of 'Introduction to the Theory of Numbers', 5th Edition, by Niven, Zuckerman & Montgomery.]

References:

1. David, M. Burton, Elementary Number Theory, 2nd Edition (UBS Publishers).

2. Niven, Zuckerman & Montgomery, Introduction to Theory of Numbers, 5th Edition (John Wiley & Sons).

3. Davenpart H., Higher Arithmetic (Camb. Univ. Press)

4. Hardy & Wright, Number Theory (Oxford Univ. Press).

5. Dence, J. B. & Dence T. P., Elements of the Theory of Numbers (Academic Press).

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Semester-II

MATH-621S : Real Analysis-II

Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note:
1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

(i) **Differentiation**: Differentiation of vector-valued functions.

(ii) **Functions of several variables:** The space of linear transformations on R^n to R^m as a metric space. Differentiation of a vector-valued function of several variables. The inverse function theorem. The implicit function theorem.

(iii) **Lebesgue measure**: Introduction. Outer measure. Measurable sets and Lebesgue measure. A non-measurable set. Measurable functions. Littlewood's three principles.

UNIT-II

(iv) **The Lebesgue integral:** The Lebesgue integral of a bounded function over a set of finite measure. The integral of a non-negative function. The general Lebesgue integral. Convergence in measure.

(v) **Differentiation and Integration**: Differentiation of monotone functions. Differentiation of an integral. Absolute continuity. Convex functions.

Scope

(i) For items (i) & (ii) as in relevant sections of Chapters 5 & 9 of the book at Sr. No. 5 in the list of references.

(ii) For items (iii) to (v) as in relevant sections of Chapters 3 to 5 of the book at Sr. No. 4 of references.

References:

1. Apostol, Tom, Mathematical Analysis - A Modern Approach to Advanced Calculus, Addison - Wesley Publishing Company, Inc. 1987. (Indian Edition by Narosa Publishing House New Delhi also available).

2. Goldberg, R.R., Methods of Real Analysis, Oxford and IHB Publishing Company, New Delhi.

3. Malik, S.C., Mathematical Analysis, Wiley Eastern, New Delhi, 1984.

4. Royden, H.L., Real Analysis, Macmillan and Co. Ltd. New York, Second Edition 1968, New York, Third Edition 2009.

5. Rudin, Walter, Principles of Mathematical Analysis, Third Edition (International Student Edition) McGraw-Hill Inc. 1983.

Math 622S: Algebra II

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:
1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT- I

Factorization Theory in Integral Domains, Divisibility, Unique Factorization Domain (UFD), Principal Ideal Domain (PID), Euclidian Domain (ED) and their relationships. Noetherian and Artinian Rings, Examples and Counter Examples, Artinian Rings without zero divisors, Nil Ideals in Artinian Rings, Hilbert Basis Theorem. [Scope as in Chapters 10 and 15 of Modern Algebra by Surjeet Singh and Qazi Zameerudin, Eighth Edition, 2006].

UNIT-II

Modules, Difference between Modules and Vector Spaces, Module Homomorphisms, Quotient Module, Completely reducible or Semisimple Modules, Free Modules, Representation and Rank of Linear Mappings, Smith normal Form over a PID, Finitely generated modules over a PID, Rational Canonical Form, Applications to finitely generated abelian groups [Scope as in Chapters 14. 20 and 21 (Sections 1, 2, 3, 4) of Basic Abstract Algebra by P. B. Bhattacharya, S. K. Jain, and S. R. Nagpal, Cambridge University Press, 1986].

References:

1. Luther, I.S. and Passi, I.B.S., Algebra, Vol. II & III, Narosa Publishing House, New Delhi.
2. Gallian, J. A., Contemporary Abstract Algebra, Narosa Publishing House, New Delhi.
3. Singh Surjeet and Qazi Zameeruddin, Modern Algebra, Vikas Publishing House, New Delhi (8^{th} Edition) 2006.
4. Herstein, I. N., Topics in Algebra (Second Edition), Wiley Eastern Limited, New Delhi.
5. Musili C, Rings and Modules (Second Revised Edition), Narosa Publishing House, New Delhi, 1994.
6. Artin, M., Algebra, Prentice Hall of India, New Delhi, 1994.
7. Bhattacharya P.B.; S.K. Jain; and S.R. Nagpal, Basic Abstract Algebra, Cambridge University Press, New Delhi.
8. Burnside W., The Theory of Groups of Finite Order (2^{nd} Ed.), Dover, New York, 1955.
9. Fraleigh, J.B., A First Course in Abstract Algebra, Narosa Publishing House, New Delhi.
10. Hartley, B and Hawkes T.O., Rings, Modules and Linear Algebra, Chapman and Hall.
11. Hungerford, T.W., Algebra, Springer, 1974.

Math 623S : Vector Analysis and Mechanics

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:
1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Vectors

Scalar and vector point functions, Differentiation and integration of vectors, Gradient divergence and curl operators, Green's and Stoke's theorems, Gauss' divergence theorem, Curvilinear co-ordinates.

[Scope as in Chapters VI & VII of the book 'A Text Book of Vector Calculus' by Shanti Narayan and J. N. Kapur, 1996, S. Chand & Company Ltd., New Delhi.]

UNIT-II

Mechanics

Generalized co-ordinates. Lagrange's equations. Hamilton's canonical equations. Hamilton's principle of least action. Reduction to the equivalent one body problem. The equations of motion and first integral. The equivalent one-dimensional problem and classification of orbits. The Viral theorem. Rigid body motion about an axis. Moving axis.

[Scope as in Chapters I-V and VIII of the book 'Classical Mechanics' by H.Goldstein, C. Poole and J. Safko, 3rd Edition, Addison Wesley (2002)].

References:

1. Weatherburn, C.E. , Advanced Vector Analysis.

2. Goldstein H., Poole, C. and Safko, J., Classical Mechanics, 3rd Edition, Addison Wesley (2002).

3. Schaum Series, Vector Analysis.

4. Shanti Narayan and J. N. Kapur, A Text Book of Vector Calculus, 1996, S. Chand & Company Ltd., New Delhi.

MATH 624S : Complex Analysis-II

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:
1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Maximum Modulus principle, Schwarz' Lemma, Taylor series and Laurent series. Singularities, Cauchy's residue theorem. Calculus of residues, bilinear transformations. Zeros and poles of meromorphic functions, Rouche's theorem, Argument Principle.

(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 6 (§6.1-§6.3), Chapter 4(§4.10-§4.12), Chapter 7, Chapter 8, Chapter 9.)

UNIT-II

Definitions and examples of conformal mappings. Infinite products, Weierstrass theorem, Mittagleffer's theorem, Canonical product, Analytic Continuation through power series (basic ideas), Natural boundary, the Gamma function and Riemann Zeta function.

(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 5, Chapter 10 (§10.1, §10.4), Chapter 11.)

References:

1. Shanti Narayan, Theory of Functions of a Complex Variable, S. Chand and Co. (Seventh Edition, 1986).

2. Ahlfors, L.V., Complex Analysis, Third Edition (International student edition) McGraw-Hill International Book Company.

3. Conway, J.B., Function of One Complex Variable, Second Edition, 1978. Corr 4th Print 1986, Graduate texts, Springer-Verlag, Indian Edition, Narosa Publishing House, New Delhi.

4. Copson, E. T., An Introduction to the Theory of Functions of a Complex Variable, The English Language Book Society and Oxford University Press, 1985.

5. Knopp, K., Theory of Functions (translated by F Bagemite) in Two Volumes, Dover Publications, Inc. New York 1945, 1947.

6. Pati, T., Functions of a Complex Variable, Allahabad Pothishala, 1971.

7. Saks, S., and Zygmund, A., Analytic Functions (Translated by E. J. Scott) Poland, Warszawa, 1952.

8. Silverman, R., Introductory Complex Analysis, Prentice-Hall Inc. Englewood Cliffs, N.J., 1967.

9. Deshpande, J.V., Complex Analysis, Tata McGraw-Hill Publishing Company Ltd., 1989.

10. Tichmarsh, E.C., The Theory of Functions, The English Language Book Society and Oxford University Press, Second Edition, 1961.

11. Tutschke Wolfgang and Vasudeva, Harkrishan L., An Introduction to Complex Analysis, Classical and Modern Approaches, Chapman and Hall/CRC, 2005.

12. S. Ponnusamy, Foundations of Complex Analysis, Second Edition, Narosa Publishing House, New Delhi, 2005.

MATH-625S : **Number Theory-II**

Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Farey sequences, Continued fractions, Approximation of reals by rationals**,** Pell's equations, Minkowski's theorem in Geometry of Numbers and its applications.

[Scope as in 6 & 7 of 'Introduction to the Theory of Numbers', 5th Edition, by Niven, Zuckerman & Montgomery.]

UNIT-II

Partitions [Scope as in Chapter 10 of 'Theory of Numbers', 5th Edition, by Niven, Zuckerman & Montgomery], Order of magnitude and average order of arithmetic functions, Euler summation formula,

[Scope as in Chapters 3 & 4 of 'Introduction to Analytic Number Theory' by T. M. Apostol.]

References:

1. David, M. Burton , Elementary Number Theory, 2nd Edition (UBS Publishers).

2. Niven, Zuckerman & Montgomer, Introduction to Theory of Numbers, 5th Edition (John Wiley & Sons).

3. Apostol, T. M., Introduction to Analytic Number Theory (Springer-Verlag).

4. Davenpart, H., Higher Arithmetic (Camb. Univ. Press).

5. Hardy & Wright, Number Theory (Oxford Univ. Press).

6. Dence, J.B, & Dence, T.P., Elements of the Theory of Numbers (Academic Press).

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SEMESTER III

MATH-617S: FIELD THEORY
(COMPULSORY COURSE)

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:
1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT I

Fields, examples, characteristic of a field, subfield and prime field of a field, field extension, the degree of a field extension, algebraic extentions and transcendental extension, Adjunction of roots, splitting fields, finite fields, existence of algebraic closure, algebraically closed fields. Separable, normal and purely inseparable extensions. Perfect fields, primitive elements. Langrange's theorem on primitive elements.

UNIT II

Galois extensions, the fundamental theorem of Galois theory, Cyclotomic extensions, and Cyclic extensions, Applications of cyclotomic extensions and Galois theory to the constructability of regular polygons, Solvability of polynomials by radicals.

References:

1. Luther and Passi, Algebra Vol 4: Field Theory (Narosa Publishing).
2. S.Singh and Q Zameeruddin, Modern Algebra (Vikas Publisher, Delhi).
3. J-P. Escofier, Galois Theory, Springer-Verlag.
4. Gallian, Contemporary Abstract Algebra, Narosa Publishing House.
5. I. Stewart, Galois Theory, Chapman and Hall.

MATH-618S: TOPOLOGY
(COMPULSORY COURSE)

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT – I

Topological Spaces, bases for a topology, the order topology, the product topology on $X \times Y$, the subspace topology, closed sets and limit points, continuous functions, the product topology, the metric topology, the quotient topology.

[Scope as in the relevant sections in Chapter 2 & 3 of the book 'Topology', second edition 2002, by James R. Munkres.]

Connected spaces, connected subspaces of the real line, components and local connectedness.

UNIT-II

Compact spaces, compact space of the real line, limit point compactness, local compactness, nets.

[Scope as in the relevant sections in Chapter 3 of the book 'Topology', second edition 2002, by James R. Munkres.]

The countability axioms, the separation axioms, Normal spaces, the Urysohn Lemma, the Urysohn Metrization Theorem, the Tietze Extension Theorem, the Tychonoff Theorem.

[Scope as in the relevant sections in Chapters 4 and 5 of the book 'Topology', second edition 2002, by James R. Munkres.]

References

1. James R. Munkers, Topology (Second Edition 2002), Prentice Hall of India.

2. James Dugundji, Topology, UBS Publishers.

3. John L. Kelley, General Topology (Van Nostrand)

4. Bourbaki , General Topology (Reading, Addison-Wesley).

5. G.G. Simmons, Introduction to Topology and Modern Analysis Tokyo, McGraw Hill, Kongakusha).

6. W.J. Thron, Topological Structures (N.Y.Holt) (Scope as in Chapters IV to XV, Chapter XVI: def. 16.4 and Results Including Tychonoff's theorem and Chapter XVIII of the reference 4).

7. E.T. Copson , Metric Spaces (Cambridge University Press).

8. S. Willord, General Topology (Addison Wesley Publishing Company).

MATH 661S: Probability and Mathematical Statistics-I

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT – I

Nature of Data and methods of compilation: Measurement scales, Attribute and variable, Discrete and continuous variables. Collection, Compilation and Tabulation of data.

Representation of data: Histogram, Frequency Polygon, Frequency Curve, Ogives.

Measures of central tendency: Mean, Median, Mode, Geometric Mean, Harmonic Mean and their properties.

Measuring variability of data: Range, Quartile deviation, Deciles and Percentiles. Standard deviation, Central and non-central moments, Sample and Population variance. Skewness and Kurtosis, Box and Whisker plot.

Correlation & Regression Analysis: Scatter diagram. Karl Pearson's and Spearman's rank correlation coefficient. Linear Regression and its properties. Theory of attributes, independence and association.

UNIT – II

Probability: Intuitive concept of Probability, Combinatorial problems, conditional probability and independence, Bayes' theorem and its applications.

Random Variables and Distributions: Discrete and Continuous random variables. Probability mass function and Probability density function. Cumulative distribution function. Expectation of single and two dimensional random variables. Properties of random variables. Moment generating function and probability generating functions.

Distributions: Bernoulli distribution. Binomial distribution. Poisson distribution, Negative Binomial and Hypergeometric distributions. Uniform, Normal distribution. Normal approximation to Binomial and Poisson distributions. Beta, Gamma, Chi-square and Bivariate normal distributions. Sampling distribution of mean and variance (normal population).

Chebyshev's inequality, weak law of large numbers, Central limit theorems.

References:

1 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-I & Vol-II (7^{th} Ed. 1998).

2Sheldon Ross : A First Course in Probability, 6th edition, Pearson Education Asia (2002).

3Meyer, P.L: Introductory Probability and Statistical Applications.

4 Hogg, R.V. and Craig, T.: Introduction to Mathematical Statistics (MacMillan 2002).

MATH-672S: COMPUTATIONAL TECHNIQUES-I

Total Marks: 100

Computational Techniques –I (Theory)

Theory (4 hours per week)
Theory marks: 60 marks
Internal Assessment : 20 marks

Note: 1. Nine questions will be set in total - four from Unit I and five from Unit II.

2. The students will be required to attempt 5 questions, selecting at least two from each Unit.

3. Use of calculator is allowed for numerical work.

UNIT-I

Programmer's model of a computer, Types of computers, General awareness of Computer Hardware – CPU, Input, Output and peripherals, Software and Programming languages, General awareness of MS – Word.

Programming in FORTRAN 77: Character set, constants, variables, Arithmetic expressions, Format specification, READ, WRITE statements, unformatted I/O Statements, Unconditional GO TO, Computed GO TO, Arithmatic and Logical IF statements, IF-THEN-ELSE, Nested IF-THEN-ELSE, ELSE-IF-THEN, DO loops, Nested DO loops, CONTINUE Statement, Data statement, Double Precision, Logical Data, Complex Data, WHILE Structure, Arrays-One and multidimensional, Subscripted Variables, Implied DO loops, Sorting Problem, Function Subprograms and Subroutine subprograms, COMMON, EQUIVALENCE, Simple programs.

UNIT-II

Solution of non-linear equations: Functional iteration, Bisection, Secant, Regula-Falsi, Newton-Raphson and Bairstow's methods, Rate of convergence of these methods, Solution of linear system of equations: Gauss elimination, Gauss Seidal and Triangularization methods, Condition of convergence of these methods.

Interpolation: Finite difference operators, Newton interpolation, Gauss Forward and backward interpolation formulae, Newton's divided difference formula, Lagrange's Formula, Inverse interpolation, Hermite interpolation.

Computational Techniques - I (Practical)

Practical (3 hours per week): 20 marks
Internal Assessment: No Marks

Writing programs in FORTRAN for the problems based on the methods studied in theory paper and to run the program of PC.

Practical examination shall be conducted by the department/college concerned as per the following distribution of marks:

Writing one Program of FORTRAN and running it on PC = 10 marks
Practical Record = 5 marks
Viva Voce = 5 marks

References:

1. C. F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Pearson Education Asia.
2. M. K. Jain, S. R. K. Iyengar, R. K. Jain: Numerical Analysis for Scientific and Engineering Computations, .New Age International (p) Ltd.
3. S. S. Shastry: Introduction to Numerical Analysis, Prentice Hall of India.
4. C. Xavier: FORTRAN 77 and Numerical Methods, New Age Int. Ltd.

MATH-673S: DIFFERENTIAL GEOMETRY-I

Total Marks	**:**	**100**
Theory	**:**	**80 Marks**
Internal Assessment	**:**	**20 Marks**
Time	**:**	**3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT I

Tensors: Notations and Summation Convention, Transformation law for vectors, Cartesian tensors, Algebra of Cartesian tensors, Differentiation of Cartesian tensors, The metric tensor, Transformation of curvilinear co ordinates, General tensors, Contravariant, Covariant derivative of a vector, Physical components, Christoffel symbol, Relation with the metric tensor, Covariant derivative of a tensor, Riemann – Christoffel curvature tensor.

UNIT-II

Curves with Torsion: Tangent, Principal normal, Curvature, Binormal, Torsion, Serret-Frenet formulae, Locus of Center of curvature, Circle of curvature, torsion of a curve, Involutes, Evolutes and Bertrand curves.

Envelopes and Developable Surfaces: Surfaces, Tangent plane, normal, Envelope, Edge of regression, Developable surfaces, Curvilinear co ordinates on a surface: Fundamental Magnitudes.

References:

1. Shanti Narayan: Cartesian Tensors, S. Chand and Company, New Delhi.
2. E. C. Young: Vectors and Tensor Analysis, Marcel Deccer (1994).
3. A. W. Joshi: Tensors and Riemanian Geometry.
4. C. E. Weatherburn: Differential Geometry.
5. A. Goetz: Introduction to Differential Geometry: Addison Wesley Publishing Company (1970).

MATH-674S: ELASTICITY –I

Total Marks	**:**	**100**
Theory	**:**	**80 Marks**
Internal Assessment	**:**	**20 Marks**
Time	**:**	**3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT I

Tensors: Summation convention, Coordinate transformation, Cartesian tensors of different orders, Sum, product and quotient laws, Contraction, Symmetric and skew symmetric tensors, Relation between alternate and Kronecker tensors, Eigen values and Eigen vectors of a tensor of order two, Three scalar invariants of a tensor of order two, Eigen vectors and values of symmetric tensors, Orthogonality of Eigen vectors and reality of Eigen values, Gradient, Divergence and Curl in tensor notations, Gauss divergence theorem.

Analysis of Strain: Affine transformation, infinitesimal affine transformation, Geometrical interpretation of component of Strain, Strain quadric of Cauchy.

UNIT-II

Analysis of Strain: Principal strains and Invariants, general infinitesimal deformation, Example of Strain, Equations of Compatibility, Finite deformations.

Analysis of Stress: Stress tensor, Equation of equilibrium, Stress quadric of Cauchy, Principal stress and invariants, Maximum normal and shear stress, Plane stress, generalized plane stress, Airy stress function, General solution of biharmonic equation, stresses and displacements in terms of complex potentials, simple problems.

References:

1. Shanti Narayan: Cartesian Tensor, Sultan Chand and Company, N. Delhi.
2. I. S. Sokolnikoff: Mathematical Theory of Elasticity, Mc-Graw Hill, Inc.
3. A. E. H. Love: A Treatise on Mathematical Theory of Elasticity, Dover Publications.
4. K. E. Bullen and B. A. Bolt: An Introduction to the Theory of Seismology, Cambridge University Press, Cambridge (1985).

MATH-675S: SPECIAL FUNCTIONS

Total Marks	**:**	**100**
Theory	**:**	**80 Marks**
Internal Assessment	**:**	**20 Marks**
Time	**:**	**3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT I

Hypergeometric Functions: The hypergeometric series, An integral formula for the hypergeometric series, The hypergeometric equation, Linear relations between the solutions of the hypergeometric equation, Relations of contiguity, The confluent hypergeometric function, Generalised hypergeometric series.

Legendre Functions: Legendre polynomials, Recurrence relations for the Legendre polynomials, The formulae of Murphy and Roderigues, Series of Legendre polynomials, Legendre's differential equation, Neumann's formula for the Legendre functions, Recurrence relations for the functions $Q_n(\mu)$, The use of Legendre functions in potential theory, Legendre's associated functions, Integral expression for the associated Legendre function, Surface spherical harmonics, Use of associated Legendre functions in wave mechanics.

UNIT II

Bessel Functions: The origin of Bessel functions, Recurrence relations for the Bessel coefficients, Series expansions for the Bessel coefficients, Integral expressions for the Bessel coefficients, The addition formula for the Bessel coefficients, Bessel's differential equation, Spherical Bessel functions, Integrals involving Bessel functions, The modified Bessel functions, The Ber and Bei functions, Expansions in series of Bessel functions, The use of Bessel functions in potential theory, Asymptotic expansion of Bessel functions.

The Functions of Hermite And Laguerre: The Hermite polynomials, Hermite's differential equation, Hermite functions, the occurrence of Hermite functions in wave mechanics, The Laguerre polynomials, Laguerre's differential equation, The associated Laguerre polynomials and functions, The wave functions for the hydrogen atom.

References:

1. I. N. Sneddon: Special Functions of Mathematical Physics and Chemistry, Edinburg, Oliver & Boyd, 1956.
2. G. Andrews, R. Askey & R. Roy, Special Functions, Cambridge, 1999.
3. L. Andrews, Special Functions for Engineers and Applied Scientists, Macmillan, 1985.
4. N. N. Lebedev, Special Functions & Their Applications, Revised Edition, Dover, 1976.
5. W. W. Bell, Special Functions for Scientists and Engineers, Dover, 1968.

MATH-676S: FLUID MECHANICS –I

Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Real fluids and ideal fluids, velocity of fluid at a point, streamlines, pathlines, streaklines, velocity potential, vorticity vector, local and particle rate of change, equation of continuity, irrotational and rotational motion, acceleration of fluid, conditions at rigid boundary.

Euler's equation of motion, Bernoulli's equation, their applications, Potential theorems, axially symmetric flows, impulsive motion, Kelvin's Theorem of circulation, equation of vorticity.

UNIT-II

Some three dimensional flows: Sources, sinks and doublets, images in rigid planes, images in solid sphere, Stoke's stream function.

Two dimensional flows: Complex velocity potential, Milne Thomson Circle Theorem and applications, Theorem of Blasius, vortex rows, Karman vortex street.

References

1. Chorlton, F. (Text Book of Fluid Dynamics).
2. L.D.Landau & E. N. Lipschitz (Fluid Mechanics).
3. G. K. Batchelor (An Introduction to Fluid Mechanics).
4. Kundu and Cohen (Fluid Mechanics).

MATH-678S: LINEAR PROGRAMMING

Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note:1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Linear Programming and examples, Convex Sets, Hyperplane, Open and Closed half-spaces, Feasible, Basic Feasible and Optimal Solutions, Extreme Point & graphical methods. Simplex method, Charnes-M method, Two phase method, Determination of Optimal solutions, unrestricted variables, Duality theory, Dual linear Programming Problems, fundamental properties of dual Problems, Complementary slackness, Unbounded solution in Primal. Dual Simplex Algorithm, Sensitivity analysis.

UNIT-II

Parametric Programming, Revised Simplex method, Transportation Problems, Balanced and unbalanced Transportation problems, U-V method, Paradox in Transportation problem, Assignment problems, Integer Programming problems: Pure and Mixed Integer Programming problems, 0-1 programming problem, Gomary's algorithm, Branch & Bound Technique. Travelling salesman problem [scope as in reference no. 2].

[Scope as in Chapter 2-5; Chapter 7-9 of the reference no.1,chapter 4-6 of reference no. 3, chapter 5 of reference no. 2].

References:

1. G. Hadley, Linear Programming, Narosa Publishing House, 6th edition. 1995.
2. N.S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press Pvt.Ltd. New Delhi, Madras.
3. Suresh Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Narosa Publishing House,1st edition,2009.
4. S.M. Sinha, Mathematical Programming, Theory and Methods, Elsevier, 1st edition, 2006.

SEMESTER IV

MATH-637S: LINEAR ALGEBRA
(COMPULSORY COURSE)

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT I

Definition and examples of vector spaces (over arbitrary fields), subspaces, direct sum of subspaces, linear dependence and independence, basis and dimensions, linear transformations, quotient spaces, algebra of linear transformations, linear functions, dual spaces, matrix representation of a linear transformation, rank and nullity of a linear transformation, invariant subspaces.

UNIT II

Characteristic polynomial and minimal polynomial of a linear transformation, eigenvalues and eigenvectors of a linear transformation, diagonalization and triangularization of a matrix, Jordan and Rational canonical forms, bilinear forms, symmetric bilinear forms, Sylvester's theorem, quadratic forms, Hermitian forms, Inner product spaces, Gram-schmidt orthonormalization process.

References:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, First Course in Linear Algebra (Wiley Eastern Delhi).

2. J. Gilbert and L. Gilbert: Linear Algebra and Matrix Theory (Academic Press).
3. S.Singh and Q Zameeruddin, Modern Algebra (Delhi, Vikas).
4. I.N. Herstein, Topics in Algebra (Delhi Vikas).
5. V.Bist and V. Sahai, Linear Algebra (Narosa, Delhi).

MATH 638S: Functional Analysis (Compulsory Course)

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Banach Spaces with examples of L^P([a,b]) and C ([a,b]), Hahn Banach theorem, open mapping theorem, closed graph theorem, Baire Category theorem, Banach Steinhauns theorem (uniform boundedness principle), Boundedness and continuity of linear transformation, Dual Spaces, embedding in second dual.

[Scope as in 3.7, §5-§7, 9.1, 9.2, 10.3-10.7, 11.1-11.3, 13.1-13.5 of the book 'Functional Analysis' by B.V. Limaye, 1985, Wiley Eastern Ltd.]

UNIT-II

Hilbert space, orthonormal basis, Bessel's inequality, Riesz Fischer theorem, Parseval's identity, bounded Linear functionals; projections, Riesz Representation theorem, adjoint operators, self adjoint, normal, unitary and isometric operators.

[Scope as in §21, §22, 23.2, 23.7-23.9, §24 upto 24.5, §25, 26.1-26.3 of the book 'Functional Analysis' by B.V. Limaye, 1985, Wiley Eastern Ltd**.]**

References:

1. S.K. Berberian - Introduction to Hilbert Spaces, (N.Y. O.W.P.).
2. C. Goffman and G. Pedrick - First course in Functional Analysis, N. Delhi Prentice Hall of India).
3. F.K. Riesz and Bela Sz Nagy - Functional Analysis, (N.Y., Wingar).
4. A.H. Siddiqui - Functional Analysis (Tata-McGraw Hill).
5. Walter Rudin – Real and Complex Analysis (McGraw-Hill) 3rd Edition.
6. B.V. Limaye – Functional Analysis (Wiley Eastern Ltd.), 1985.

MATH 681S: Probability and Mathematical Statistics-II

Total Marks	**:**	**100**
Theory	**:**	**80 Marks**
Internal Assessment	**:**	**20 Marks**
Time	**:**	**3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Point and Interval Estimation: General concept of Point estimation, unbiasedness, consistency, efficiency and Sufficiency. Factorization theorem, completeness, Rao-Blackwell theorem, Cramer-Rao inequality. Maximum likelihood method of estimation and method of moments. Interval estimation, confidence intervals for means, difference of means and variances.

UNIT–II

Hypothesis Testing: The basic idea of significance test. Null and alternative hypothesis, Type-I and Type-II errors. Uniformly most powerful tests, Likelihood Ratio tests. t, Chi-square and F-distributions. Tests of significance based on t, Chi-square and F. One way and two way Analysis of Variance (ANOVA).

Non-Parametric Tests: Sign test, Wilcoxon signed rank test, Mann-whitney test.

References:

1 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-I (7^{th} Ed. 1998).

2Dudewicz, E.J and Mishra, S.N: Modern Mathematical Statistics (1988).

3Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-II (7^{th} Ed. 1998).

4Deniel, W.W: Aplied Nonparametric Statistics (1999).

5Rohtagi, V.K and Saleh A.K.M.E.: An Introduction to Probability Theory Mathematical Statistics (2000).

MATH-692S: COMPUTATIONAL TECHNIQUES-II

Total Marks: 100

Computational Techniques –II (Theory)

Theory (4 hours per week)
Theory marks: 60 marks
Internal Assessment : 20 marks

Note: 1. Nine questions will be set in total - four from Unit I and five from Unit II.

2. The students will be required to attempt 5 questions, selecting at least two from each Unit.

3. Use of calculator is allowed for numerical work.

UNIT-I

MS Excel: Introduction, Functions and Formulae, Graphics and Data base.

Programming in C: Historical development of C, Character set, Constants, Variables, Keywords, Operators, Hierarchy of arithmetic operations, if and if-else statements, Logical and Conditional Operators, Switch structure, while structure, do-while and for-Loops, Nested loops, Break and Continue statements, Arrays, Functions, Print Function, Function Declaration and Function Prototype, Return Statement, Local and Global Variables, Passing Arrays as parameter, Recursion and Library Functions, Files in C, Introduction to pointers, Simple programs.

UNIT-II

Numerical Differentiation, Numerical Integration: General formulae, Trapeziodal rule, Simpson's 1/3 and 3/8 rule, Romberg integration, Newton-Cotes formulae, Gaussian integration.

Solution of Ordinary Differential Equations: Taylor's series, Picard method of Successive approximations, Euler's method, Modified Euler's method, Runge Kutta Method-2^{nd} and 4^{th} order, Predictor-Corrector methods, Milne-Simpson's method, Adam's – Bashforth method, Finite difference method for boundary value problems.

Approximation of functions: Chebyshev Polynomials, Orthogonality of Chebyshev polynomials, Lanczos Economization of Power series.

Computational Techniques –II (Practical)

Practical (3 hours per week): 20 marks

Internal Assessment : No marks

Writing programs in C for the problems based on the methods studied in theory paper and to run the program of PC.

Practical examination shall be conducted by the department/college concerned as per the following distribution of marks:

Writing one Program of C and running it on PC = 10 marks
Practical Record = 5 marks
Viva Voce = 5 marks

References:

1. C. F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Pearson Education Asia.
2. M. K. Jain, S. R. K. Iyengar, R. K. Jain: Numerical Analysis for Scientific and Engineering Computations. New Age International (p) Ltd.
3. S. S. Shastry: Introduction to Numerical Analysis, Prentice Hall of India.
4. C. Xavier: C Language and Numerical Methods, New Age Int. Ltd.
5. Y. Kanetkar: Let Us C, B P B Publication.

MATH-693S: DIFFERENTIAL GEOMETRY-II

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT I

Curves on a Surface: Principal directions and curvature, First and second curvature, Euler's theorem, Dupin theorem, Dupin's indicatrix, Normal curvature, Mean curvature, Umblic points, Conjugate directions, conjugate system, asymptotic lines, Curvature and Torsion, Isometric lines, Null lines.

UNIT II

Equations of Gauss and of Codazzi: Gauss's formulae for r_{11}, r_{12}, r_{22}, Gauss Characteristic equation, Mainardi-Codazzi relation, Bonnet's theorem.

Quadric Surfaces: Geodesics, Geodesic property, equation of geodesics, surface of revolution, Torsion of geodesic, Central quadrics, Fundamental magnitudes, The fundamental theorem of surface theory, Liouville's equation, Joachimsthal's theorem.

References:

1. C. E. Weatherburn: Differential Geometry.
2. A. Goetz: Introduction to Differential Geometry: Addision Wesley Publishing Company, (1970).

MATH-694S: ELASTICITY –II

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT I

Equations of Elasticity: Generalized Hook's Law, Homogeneous isotropic media, Equilibrium and dynamical equations for isotropic media, Strain energy function, Uniqueness of solution, Beltrami-Michell Compatibility equations, Saint Venant's Principal.

D'Alembert's method of one dimensional wave equation, Waves in three dimensions, Harmonic waves, Spherical waves, Superposition of waves and stationary waves, Solution of equation of wave motion of stationary type by method of separation of variables, Cartesian, plane polar and spherical polar coordinates.

UNIT-II

Elastic Waves: Wave propagation in isotropic elastic solid medium, Waves of dilation and distortion, Rayleigh waves, Love waves, Reflection of P, SV and SH-waves from free surface of a half-space, Reflection and refraction of elastic waves (P, SV and SH-waves) at Solid-Solid and Solid-Liquid interface.

References:

1. P. K. Ghosh, The Mathematics of Waves and Vibrations, Macmillan Company of India Limited.
2. I. S. Sokolnikoff: Mathematical Theory of Elasticity, Mc-Graw Hill, Inc.
3. A. E. H. Love: A Treatise on Mathematical Theory of Elasticity, Dover Publications.
4. K. E. Bullen and B. A. Bolt: An Introduction to the Theory of Seismology, Cambridge University Press, Cambridge (1985).
5. P. M. Shearer: Introduction to Seismology, Cambridge University Press (1999).

MATH 695S: INTEGRAL TRANSFORMS AND THEIR APPLICATIONS

Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note:
1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT I

Laplace Transforms : Definition and examples, Existence theorem and basic properties, Convolution theorem and properties of convolution, Differentiation and Integration of Laplace transform, the inverse Laplace transform and examples, Tauberian theorems for Laplace transforms and Watson's Lemma, Laplace transforms of fractional integrals and fractional derivatives.

Applications of Laplace Transform to Solve/Evaluate : Ordinary and partial differential equations, Initial and boundary value problems, Integral equations, Definite integrals, Difference equations and Differential-difference equations.

Finite Laplace Transforms : Definition and examples, Basic operational properties, Applications, Tauberian theorems for finite Laplace transforms.

Hankel Transforms : Definition and examples, operational properties, Applications to solve partial differential equations.

UNIT II

Fourier Transforms : Fourier Integral formulas, Definition and examples, Basic properties, Fourier cosine and sine transforms and examples, Basic properties of Fourier cosine and sine transforms, Multiple Fourier transforms.

Applications of Fourier Transform to Solve/Evaluate : Ordinary and Partial differential equations, Integral equations, Definite integrals. Applications of Multiple Fourier transform.

Finite Fourier Cosine and Sine Transforms : Definition and examples, Basic properties, Applications, Multiple finite Fourier transforms and their applications.

Mellin Transforms : Definition and examples, Basic operational properties and Applications.

References :

1. Loknath Debnath, Integral Transforms and Their Applications, CRC Press, Inc., 1995.

2. Brian Davies, Integral Transforms and their Applications, 3rd Edition, Springer-Verlag, New York, Inc, 2001.

3. Ronald N. Bracewell, Fourier Transform and Its Applications, 2nd Edition, McGraw-Hill Inc., US, 1986.

4. Joel L. Schiff, The Laplace Transform: Theory and Applications, Springer-Verlag, New York, Inc, 1999.

5. P.P.G. Dyke, An Introduction to Laplace Transforms and Fourier Series, Springer-Verlag, London, 2001.

6. Austin Keane, Integral Transforms, Science Press, 1965.

MATH 696S : Fluid Mechanics-II

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note:1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Viscous Flows: Stress components, Stress and strain tensor, coefficient of viscosity and Laminar flow, plane Poiseuille flows and Couette flow. Flow through tubes of uniform cross section in the form of circle, Ellipse, equilateral triangle, annulus, under constant pressure gradient.

Diffusion of vorticity. Energy dissipation due to viscosity, steady flow past a fixed sphere, dimensional analysis, Reynold numbers, Prandtl's boundary layer, Boundary layer equation in two dimensions, Karman integral equation.

UNIT-II

Elements of wave motion, waves in fluids, surface gravity waves, standing waves, dispersion relation, path of particles, waves at the interface of two liquids, equipartition of energy, group velocity, energy of propagation of waves.

References

1. Chorlton, F. (Text Book of Fluid Dynamics).
2. L.D.Landau & E. N. Lipschitz (Fluid Mechanics).
3. G. K. Batchelor (An Introduction to Fluid Mechanics).
4. Kundu and Cohen (Fluid Mechanics).

MATH 698S : Non-Linear Programming

Total Marks	**: 100**
Theory	**: 80 Marks**
Internal Assessment	**: 20 Marks**
Time	**: 3 hrs.**

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Nonlinear Programming: Convex functions, Concave functions, Definitions and basic properties, subgradients of convex functions, Differentiable convex functions, Minima and Maxima of convex function and concave functions. Generalizations of convex functions and their basic properties.

Unconstrained problems, Necessary and sufficient optimality criteria of first and second order. First order necessary and sufficient Fritz John conditions and Kuhn-Tucker conditions for Constrained programming problems with inequality constraints, with inequality and equality constraints. Kuhn Tucker conditions and linear programming problems.

UNIT-II

Duality in Nonlinear Programming, Weak Duality Theorem, Wolfe's Duality Theorem, Hanson-Huard strict converse duality theorem, Dorn's duality theorem, strict converse duality theorem, Dorn's Converse duality theorem, Unbounded dual theorem, theorem on no primal minimum. Duality in Quadratic Programming.

Quadratic Programming:Wolfe's method, Beale's method for Quadratic programming.

Linear fractional programming, method due to Charnes and Cooper. Nonlinear fractional programming, Dinkelbach's approach.

Game theory - Two-person, Zero-sum Games with mixed strategies, graphical solution, solution by Linear Programming.

[Scope as in Chapter 17 of reference no. 4, Chapter 3 & 4 of reference no.1, chapter 24, 26 and 28 of reference no. 2, Chapter 8 of reference no. 3, Chapter 16 of reference no. 5]

References :

1. Mokhtar S. Bazaraa & C.M. Shetty, Nonlinear Programming, Theory of Algorithms, 2nd edition, Wiley, New-York, 2004.

2. S. M. Sinha, Mathematical Programming, Theory and Methods, Elsevier, 1st edition, 2006.

3. O. L. Mangasarian, Nonlinear Programming, TATA McGraw Hill Company Ltd. (Bombay, New Delhi), 1st edition, 1969.

4. Kanti Swarup, P.K. Gupta & Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi 9th edition, 2001.

5. N. S. Kambo, Mathematical Programming Techiques, Affiliated East-West Press Pvt. Ltd., New Delhi, Madras.

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