COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60193MA101	**FUNDAMENTALS OF DIFFERENCE EQUATIONS**	**2**	**0**	**0**	**2**

Course Category: INSTITUTE ELECTIVE

a. Preamble

The aim of this course is to Introduce difference equations and their applications to the students. Emphasis will be laid on solving linear equations, z- transform and stability theory.

b. **Prerequisite Courses**:

Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:

Ordinary Differential Equations

d. **Course Educational Objectives**:

The course seeks to introduce to the students the fundamental concepts of difference equations

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Understand the difference operator	K3
CO2	Handle approximate summation	K3
CO3	Solve linear difference equations	K3
CO4	Know the elementary properties of Z transform and inverse Z transform	K3
CO5	Solve linear difference equations using Z transform	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO2	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO3	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO4	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO5	**H**	**H**	**M**	**M**		**M**	**M**					**M**

H – High; M – Medium; L – Low

g. Course Content

Unit-I Difference Operator

The Difference Operator-Summation-

UNIT - II Generating Functions

Generating Functions and Approximate Summation.

Unit-III Linear Difference Equations

First order equations – General Results for Linear Equations-Solving Linear equations.

Unit-IV The Z -transform

The Z –Transform – Elementary properties of Z –Transform – Inverse Z –Transform – Convolution - Examples

UNIT – V Solution of Difference Equations

Solving difference equations using Z – Transform – Initial value problem

h. Learning Resources

i. Text book

Treatment and Content as in:

W.G.Kelley and A.C.Peterson: Difference Equations, An Introduction with Applications, Academic Press, Second Edition, New York, **2001**.

ii. Reference books:

1. R.P.Agarwal, Difference Equations and Inequalities, Mercel Dekker, New York, **2000**
2. S.N.Elaydi, An Introduction to Difference Equations, Springer Verlag, New York, **1996**.
3. S.Goldberg, Introduction to Difference Equations, Dover Publications, **1986**.
4. R.E. Mickens, Difference equation - Theory and Application, Chapman and Hall, Second Edition, New York , **1990**

iii. Online Resources:

1. https://epdf.pub/difference-equations-an-introduction-with-applications-2nd-edition.html
2. https://en.wikipedia.org/wiki/Finite_difference
3. https://www.diva-portal.org/smash/get/diva2:162794/FULLTEXT01.pdf
4. https://en.wikipedia.org/wiki/Generating_function
5. https://aofa.cs.princeton.edu/30gf/
6. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-042j-
7. mathematics-for-computer-science-fall-2010/readings/MIT6_042JF10_chap12.pdf
8. http://www.math.cmu.edu/~jmackey/math301/combinatorics_day_22.pdf
9. https://math.hawaii.edu/~yuen/242handouts/Math242-chapters-16-17.pdf
10. http://people.uncw.edu/hermanr/mat361/ODEBook/Systems.pdf
11. https://users.math.msu.edu/users/gnagy/teaching/ode.pdf
12. http://mathfaculty.fullerton.edu/mathews/c2003/ZTransformIntroMod.html
13. http://rmd.ac.in/dept/eie/notes/3/TPDE/unit5.pdf
14. https://www.brainkart.com/article/Z-Transforms-and-Difference-Equations_6507/
15. https://aofa.cs.princeton.edu

COURSE CODE	COURSE TITLE	L	T	P	C
60193MA102	STOCHASTIC PROCESSES	2	0	0	2

Course Category: INSTITUTE ELECTIVE

a. Preamble

This course aims at providing the necessary basic concepts in stochastic processes. Knowledge of fundamentals and applications of random phenomena will greatly help in the understanding of topics such as signals and systems, pattern recognition, voice and image processing and filtering theory. Emphasis will be laid on the stochastic models for many real life probabilistic situations such as Markov process, renewal process and queueing system.

b. **Prerequisite Courses**:
Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:
Combinatorics
Queueing Theory

d. **Course Educational Objectives**:

The course seeks to enable the students to work creatively on scientific and engineering-based real world problems involving stochastic modelling. The students would understand and characterize phenomena which evolve with respect to time in a probabilistic manner.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Explain the fundamentals of a stochastic process	K3
CO2	Understand Markov chains and determine the stability of a Markov system	K3
CO3	Identify and work on Markov process.	K3
CO4	Describe renewal processes in continuous time	K3
CO5	Analyze transient behaviour of Queuing models	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**			**M**					**M**	**M**
CO2	**H**	**H**	**M**			**M**					**M**	**M**
CO3	**H**	**H**	**M**			**M**					**M**	**M**
CO4	**H**	**H**	**M**			**M**					**M**	**M**
CO5	**H**	**H**	**M**			**M**					**M**	**M**

H – High; M – Medium; L - Low

g. Course Content

Unit-I Stochastic Processes and Stationary processes

Stochastic Processes - Some notions – Specification of Stochastic processes Stationary processes – Markov Chains – Definitions and examples –Transition probabilities.

Unit-II Markov chains and transition probabilities

Markov chains - Classification of states and chains – determination of transition probabilities – stability of a Markov system – Reducible chains – Markov chains with continuous state space.

Unit- III Continuous time Markov Chains

Markov processes with Discrete state space – Markov processes with discrete state space (continuous time Markov Chains).

Unit-IV Renewal processes

Renewal processes and theory - Renewal process – Renewal processes in continuous time – Renewal equation – stopping time.

Unit- V Queuing model

Stochastic processes in Queuing – Queuing system – General concepts – The queuing model M/M/1 – Steady state behaviour – transient behaviour of M/M/1 Model.

h. Learning Resources

i. Text book

Treatment and Content as in:

J. Medhi, Stochastic Processes, Wiley Eastern, **1982**.

ii. Reference books

1. S.Karlin, H.M.Taylor, A First Course in Stochastic Processes, Academic Press, 2nd Edition, **1975**.
2. N.Bhat, Elements of Applied Stochastic Processes, John Wiley, 2nd Edition, **1984**.
3. S.K. Srinivasan and K.Mehata, Stochastic Processes, Tata McGraw Hill, **1976**.
4. N.U. Prabhu, Stochastic Processes. Macmillan, **1965.**
5. Howard M. Taylor, Samuel. Karlin, Introduction to Stochastic Modeling, Gulf Professional Publishing, 3rd Edition, 1998.

iii. Online Resources

1. http://home.iitk.ac.in/~skb/qbook/Slide_Set_2.PDF
2. http://www.stat.yale.edu/~pollard/Courses/251.spring2013/Handouts/Chang-MarkovChains.pdf
3. http://www.few.vu.nl/~wvanwie/Courses/BiomedicalMathematics/WNvanWieringen_Lecture1_MarkovChain_1_20112012.pdf
4. https://link.springer.com/content/pdf/10.1007%2F978-1-4757-4070-7_7.pdf
5. https://bookdown.org/probability/beta/markov-chains.html
6. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-262-
7. http://pages.iu.edu/~rdlyons/pdf/StochProc.pdf
8. https://www.kent.ac.uk/smsas/personal/lb209/files/sp07.pdf
9. https://arxiv.org/pdf/1307.2968
10. http://www.math.uchicago.edu/~may/VIGRE/VIGRE2011/REUPapers/Constantin.pdf
11. https://www.researchgate.net › publication › 27289422_Stochastic_Processes...
12. https://www.me.utexas.edu › powerpoint › or_models › 11_stoch_processes.

COURSE CODE	COURSE TITLE	L	T	P	C
60193MA103	DESIGN AND ANALYSIS OF ALGORITHMS	2	0	0	2

Course Category: INSTITUTE ELECTIVE

a. Preamble

The course aims to train the students in Analysis of the asymptotic performance of algorithms. Writing rigorous correct proof for a given algorithms Demonstrating familiarity with major algorithms and data structures. Applications of important algorithmic design paradigms and methods of analysis.

b. **Prerequisite Courses**:

Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:

Advanced Algebra
Graph Theory
Discrete Mathematics
Number Theory
Combinatorics

d. Course Educational Objectives:

The course seeks to provide to the students the fundamental principles in the design and analysis of algorithms which will be helpful in the development of computer programs or the usage of software packages.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Explain the fundamental principle of algorithms	K3
CO2	Understand the sorting algorithms	K3
CO3	Appreciate graph algorithms	K3
CO4	Know the techniques involved in the string matching algorithm	K3
CO5	Grasp the concept of NP completeness	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**		**M**							**M**
CO2	**H**	**H**	**M**		**M**							**M**
CO3	**H**	**H**	**M**		**M**							**M**
CO4	**H**	**H**	**M**		**M**							**M**
CO5	**H**	**H**	**M**		**M**							**M**

H – High; M – Medium; L - Low

g. Course Content

Unit- I Analyzing algorithms

Algorithms – Analyzing algorithms – Designing algorithms – Growth of functions – Recurrences.

Unit-II Sorting

Insertion sort – Quick sort – Divide and Conquer – Mergesort – Heapsort.

Unit- III Graph algorithms

Representations of graphs – Breadth-first search – Depth-first search – Minimum spanning tree – The algorithms of Kruskal and Prim.

Unit-IV String matching

The naïve string-matching algorithm – String matching with finite automata – The Knuth-Morris – Pratt algorithm.

Unit-V Polynomials and NP completeness

Representation of polynomials – Polynomial time – The complexity class NP – NP completeness – NP complete problems.

h. Learning Resources

i. Text Book:

Treatment and Content as in:

T.H.Cormen, C.E.Leiserson and R.L.Rivest, Introduction to Algorithms, 2nd Edition, Prentice Hall of India, New Delhi, **2004**.

ii. Reference books

1. A. V. Aho, J. E. Hopcroft, J. D. Ullman, The Design and Analysis of Computer Algorithms, Addison-Wesley Publishing Co., **1975.**
2. S.Baase, Computer Algorithms: Introduction to Design and Analysis, 2nd edition, Addison and Wesley, **1993**.
3. E. Horowitz, S. Sahni, Fundamental of Computer Algorithms, Galgotia Publication, **1987**.
4. D. E. Knuth, The Art of Computer Programming Vol. 1, Vol. 2, Vol 3, Addison Wesley Publishing Co., **1997**.
5. A.Levitin, Introduction to the Design & Analysis of Algorithms, Pearson Education (Asia) Pvt. Ltd., New Delhi, **2003**.

iii. Online Resources:

1. https://www.javatpoint.com/daa-tutorial
2. http://ignou.ac.in/userfiles/SandeepFINAL_Unit1_Intro_21-03-2013.pdf
3. http://www.vssut.ac.in/lecture_notes/lecture1428551222.pdf
4. http://www.cse.iitd.ernet.in/~ssen/csl356/root.pdf
5. http://dmice.ac.in/wp-content/uploads/2017/05/DAA.pdf
6. https://www.geeksforgeeks.org/quick-sort-vs-merge-sort/
7. https://en.wikipedia.org/wiki/Sorting_algorithm
8. https://www.hackerearth.com/practice/algorithms/sorting/merge-sort/tutorial/
9. https://www.cs.cmu.edu/~adamchik/15-121/lectures/Sorting%
10. https://visualgo.net/bn/sorting
11. https://www3.ntu.edu.sg/home/ehchua/programming/cpp/DataStructureAlgorithm.html
12. https://www.tutorialspoint.com/parallel_algorithm/graph_algorithm
13. https://pdfslide.net/education/introduction-to-algorithms-3rd-edition-by-coreman.html
14. https://www.cs.auckland.ac.nz/courses/compsci369s1c/lectures/GG-notes/CS369-StringAlgs.pdf
15. https://www.geeksforgeeks.org/kmp-algorithm-for-pattern-searching/

COURSE CODE	COURSE TITLE	L	T	P	C
60193MA104	ALGEBRAIC CODING THEORY	2	0	0	2

Course Category: INSTITUTE ELECTIVE

a. Preamble

Coding Theory helps to detect errors in transmission of messages.

b. Prerequisite Courses:
Mathematics as a Main Subject or Allied Subject in UG Level

c. Related Courses:
Cryptography

d. Course Educational Objectives:
This course seeks to introduce to the students the basic concepts of Coding Theory. The students will understand different types of codes and learn how algebraic coding theory is applicable in real world problems.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Comprehend various error control code properties, error detection, error correction and maximum likelihood decoding	K3
CO2	Understand the concepts of generator matrix, parity check matrix , syndrome decoding.	K3
CO3	Learn different bounds in coding theory	K3
CO4	Know cyclic codes and generator polynomials	K3
CO5	Appreciate BCH codes and their parameters	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**			**M**	**M**						**M**
CO2	**H**	**H**			**M**	**M**						**M**
CO3	**H**	**H**			**M**	**M**						**M**
CO4	**H**	**H**			**M**	**M**						**M**
CO5	**H**	**H**			**M**	**M**						**M**

H – High; M – Medium; L - Low

g. Course Content

Unit-I Basic concepts of coding

Error detection, Correction and decoding Communication channels – Maximum likelihood decoding – Hamming distance – Nearest neighbourhood minimum distance decoding.

Unit-II Linear codes

Linear codes – Self orthogonal codes – Self dual codes – Bases for linear codes – Generator matrix and parity check matrix – Encoding with a linear code – Decoding of linear codes – Syndrome decoding.

Unit-III Bounds in coding theory

Bounds in coding theory – Sphere - covering bound – Gilbert Varshamov bound – Singleton bound and MDS codes – Plotkin bound.

Unit-IV Cyclic codes

Cyclic codes Definitions – Generator polynomials – Generator matrix and parity check matrix – Decoding of Cyclic codes.

Unit-V Special cyclic codes

Special cyclic codes - BCH codes – Parameters of BCH codes – Decoding of BCH codes.

h. Learning Resources

i. Text book

S.Ling and C.Xing; Coding Theory: A First Course, Cambridge University Press, Cambridge, **2004**.

ii. Reference books

1. E.R.Berlekamp, Algebraic Coding Theory, World Scientific Publishing, Revised Edition,**2014**
2. R.Hamming, Coding and Information Theory; Prentice Hall
3. W. C. Huffman and V. Pless, Fundamentals of Error-Correcting Codes, Cambridge University Press, Cambridge, Reprint, **2010.**
4. T.Klove, Codes for error Detection, Series on Coding Theory and Cryptology, Vol. 2, World Scientific Publishing Co. Private. Ltd., **2007**
5. S.Lin and D. J. Costello, Error Control Coding-Fundamentals and Applications, Pearson Education India, **2011**
6. J.H.van Lint, Introduction to Coding Theory, 3rd Edition, Graduate Texts in Mathematics, 86. Springer-Verlag, Berlin,**1999**
7. F.J.MacWilliams and N.J.A.Sloane, The Theory of Error-correcting Codes. Vol. 16, North Holland Mathematical Library, North-Holland Publishing Co., New York, **1977**.
8. A. Neubauer, J. Freudenberger, V. Kuhn, Coding Theory: Algorithms, Architectures and Applications, John Wiley & Sons Ltd, England, **2007**
9. W.W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes, M.I.T. Press, Cambridge, Massachusetts, **1972.**
10. V. Pless, Introduction to the Theory of Error Correcting Codes, John Wiley& Sons, New York, **1982**
11. R. Hill, A First Course in Coding Theory, Oxford University Press, **1990**.
12. R. Lid and Pilz , Applied Abstract Algebra - 2nd Edition.
13. R. Lidl, H.Neiderreiter , Introduction to finite fields and their applications, Cambridge University Press.
14. S. Lin, An Introduction to Error-Correcting Codes, Prentice-Hall, **1970**.
15. T. Richardson and R.Urbanke, Modern Coding Theory, Cambridge University Press, Cambridge, **2007**.
16. Roman, Coding and Information Theory; Springer-Verlag.
17. N. J. A. Sloane, F. J. MacWilliams, Theory of Error Correcting Codes, North-Holland Mathematical Library 16, North-Holland, **2007.**
18. L.R. Vermani, Elements of Algebraic Coding, Chapman and Hall, **1996.**

iii. Online Resources:

1. https://www.sciencedirect.com › topics › engineering › hamming-distance
2. https://www.fi.muni.cz › usr › gruska › crypto13 › crypto_01
3. https://ocw.mit.edu › courses › aeronautics-and-astronautics › lecture-notes
4. https://people.cs.umass.edu › ~arya › courses › lectures1-2
5. https://www.famnit.upr.si › resources › files › knjiznica › studijsko-gradivo

6. https://books.google.co.in › books
7. https://users.math.msu.edu › users › jhall › classes › codenotes › Linear
8. https://www.cs.cmu.edu › ~venkatg › teaching › codingtheory › notes1
9. https://www.famnit.upr.si › files › epasalic-studijsko-gradivo-linear-codes
10. https://www.gap-system.org › Manuals › pkg › guava3.11 › doc › chap4
11. www.math.titech.ac.jp › ~shanekelly › LinearCodes2016-17WS
12. https://www.cs.cmu.edu › ~venkatg › teaching › codingtheory › notes4
13. https://www.math.uci.edu › ~nckaplan › teaching_files › kaplancodingnotes
14. https://people.cs.umass.edu › ~arya › courses › lecture4
15. https://www.mathematik.uni-wuerzburg.de › ~mueller › Teach › coding

COURSE CODE	COURSE TITLE	L	T	P	C
60193MA105	CRYPTOGRAPHY	2	0	0	2

Course Category: INSTITUTE ELECTIVE

a. Preamble

Cryptography deals with transmission of secret messages in coded form. This subject has grown with the immense use of Number Theory.

b. **Prerequisite Courses**:

Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:

Algebraic Coding Theory

d. **Course Educational Objectives**:

The students will be introduced to the Mathematics behind some of the Cryptographic Schemes.

e . Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Learn the basics of Number Theory required for Cryptography	K3
CO2	Encrypt and decrypt messages and learn linear block ciphers	K3
CO3	Understand Public Key Encryption and RSA-Cryptosystem	K3
CO4	Know Cryptographic Hash Functions	K3
CO5	Appreciate Digital Signatures and RSA Signatures	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**		**M**	**M**		**M**				**M**
CO2	**H**	**H**	**M**		**M**	**M**		**M**				**M**
CO3	**H**	**H**	**M**		**M**	**M**		**M**				**M**
CO4	**H**	**H**	**M**		**M**	**M**		**M**				**M**
CO5	**H**	**H**	**M**		**M**	**M**		**M**				**M**

H – High; M – Medium; L - Low

g. Content

Unit I Basic concepts of number theory

Euclidian Algorithm, Extended Euclidian Algorithm. Factoring into primes. Congruences and Residue Class Rings, Multiplicative group of residues mod n . Euler-Fermat Theorem.

Unit II Block cyphers

Encryption, Symmetric and Asymmetric Cryptosystems, Linear Block Ciphers and its Crypto analysis. Probability and Perfect Secrecy, Fermat Test, Carmichael Numbers, Miller-Rabin-Test.

Unit III Public Key cryptography

Public Key Encryption - Idea, Security, RSA-Cryptosystem, Diffie-Hellmann Key Exchange. .

Unit IV Message Authentication Code

Cryptographic Hash functions, Compression functions - Message Authentication Code (MAC)

Unit V Digital Signatures

Digital Signatures - Idea, Security, RSA signatures.

h. Learning Resources

i. Text Book

J.A. Buchmann, Introduction to Cryptography, 2nd Edition, Springer,

ii. Reference books

1. S.D. Galbraith, Mathematics of Public Key Cryptography, Cambridge University Press.
2. O. Goldreich, Foundations of Cryptography - Vol. I and Vol. II, Cambridge University Press, **2001**,
3. S. Goldwasser and Mihir Bellare, Lecture Notes on Cryptography **2008**, available online from http://cseweb.ucsd.edu/ mihir/papers/gb.html
4. J.Katz and Y.Lindell, Introduction to Modern Cryptography; Chapman and Hall, CRC.
5. A. J. Menezes, P.C. van Oorschot and S.A. Vanstone, Handbook of Applied Cryptography, CRC Press, **1996**
6. A. Mollin, An Introduction to Cryptography, Chapman & Hall / CRC, Boca Raton, **2000**
7. D. R. Stinson, Cryptography; Theory and Practice; CRC Press Company, **2002.**
8. D.Walsh, Codes and Cryptography, Oxford Science Publications, Clarendon Press, Oxford, **1988.**

iii. Online Resources

1. https://www.maths.tcd.ie › Courseware › NumberTheory › NumberTheory
2. https://www.ams.org › authors › books › postpub › gsm-160-summary
3. https://www.math.uci.edu › ~ndonalds › notes
4. link.springer.com › content › pdf › bfm:978-1-4419-9003-7 › 1.pdf
5. https://www.cs.umd.edu › ~waa › IntroToCrypto
6. https://www.venafi.com › blog › how-diffie-hellman-key-exchange-differe...
7. https://www.comparitech.com › Blog › Information Security
8. rmd.ac.in › dept › notes › CNS › unit2
9. https://cseweb.ucsd.edu › ~mihir › papers › kmd5
10. https://www.cs.bham.ac.uk › ~mdr › teaching › crypto16 › crypto6
11. https://www.famnit.upr.si › knjiznica › epasalic-hashfunc-zbirka-nalog-2
12. https://www.cs.cornell.edu › courses › notes › rsa_sign_vs_dec
13. https://medium.com › coinmonks › a-laymans-explanation-of-public-key-c...
14. https://www.cs.purdue.edu › 526_Fall14 › handouts › 14_526_topic06

COURSE CODE	COURSE TITLE	L	T	P	C
60193MA106	LINEAR PROGRAMMING AND OPERATIONS RESEARCH	2	0	0	2

Course Category: INSTITUTE ELECTIVE

a. Preamble

Operations research helps in solving problems in different environments that require decisions. The students will be introduced to techniques for effective decision making, model formulation and solutions required to solve organizational problems.

b. **Prerequisite Courses**:

Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:

Linear Algebra
Optimization Techniques

d. **Course Educational Objectives**:

The aim of this course is to introduce the field of operations research to the students so as to enable them to apply certain techniques in business and management problems. Basic concepts of Operations Research such as Linear Programming Problem, Network models, Minimal spanning tree algorithm, Shortest route problem, Integer Programming, Decision trees, Two - Person, Zero - Sum Games, etc. will be introduced.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Familiarize with the basic concepts of Linear Programming and examples of LPP	K3
CO2	Solve a Linear Programming Problem by Graphical Method and Simplex Method	K3
CO3	Understand the technique of simplex method.	K3
CO4	Learn the techniques of solving network problems	K3
CO5	Know the methods of solutions of Two - Person, Zero - Sum Games	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**			**M**					**M**	**M**
CO2	**H**	**H**	**M**			**M**					**M**	**M**
CO3	**H**	**H**	**M**			**M**					**M**	**M**
CO4	**H**	**H**	**M**			**M**					**M**	**M**
CO5	**H**	**H**	**M**			**M**					**M**	**M**

H – High; M – Medium; L - Low

g. Course Content:

Unit - I Basic concepts of linear programming

Hyper-planes and half-spaces – Supporting and separating hyper planes – Convex functions – Linear programming basic concepts – Convex sets – Linear programming problems – Examples of LPP – Feasible, basic feasible and optimal solutions – Extreme points.

Unit-II Graphical Method

Linear Programming – Graphical Method

Unit-III Simplex Method

Linear Programming - Simplex Method – Simple problems.

Unit-IV Network Problems

Network models – Network definitions – Minimal spanning tree algorithm – Shortest route problem.

Unit-V Game Theory

Game Theory - Two - Person, Zero - Sum Games - Games with Mixed Strategies - Graphical Solution

Learning Resources:

h. Text book:

Treatment and Content as in:

1. H.A.Taha: Operations Research, Fourth Edition, **1971.**

ii. **Reference books**:

1. J.K.Sharma: Mathematical Models in Operations Research, Tata McGraw Hill, **1990**

iii. **Online Resources**:

1. https://www.ikbooks.com/home/samplechapter?filename=59_Sample_Chapter.pdf
2. https://wps.prenhall.com/wps/media/objects/14127/14466190/online_modules/taylor_ims11_module_B.pdf
3. http://www.universalteacherpublications.com/univ/ebooks/or/Ch14/examp1.htm
4. https://www.manage.gov.in/studymaterial/PM.pd
5. www.ist.edu.pk › cacss › national › optimum-engineering-design-workshop
6. https://www.ikbooks.com › home › samplechapter › filename=59_Sample...
7. https://www.analyticsvidhya.com › blog › 2017/02 › lintroductory-guide-...
8. https://docs.oracle.com › appdev.102 › sdo_net_concepts
9. web.mit.edu › www › AMP-Chapter-08
10. https://www.geeksforgeeks.org › dijkstras-shortest-path-algorithm-greedy-...
11. https://www.geeksforgeeks.org › kruskals-minimum-spanning-tree-algorith...
12. https://www.ics.uci.edu › ~eppstein
13. https://imada.sdu.dk › ~marco › Notes › dm545-main
14. https://pdfs.semanticscholar.org › ...
15. https://www.msuniv.ac.in › Download › Pdf

COURSE CODE	COURSE TITLE	L	T	P	C
60193MA107	FINANCIAL MATHEMATICS	2	0	0	2

Course Category: INSTITUTE ELECTIVE

a. Preamble

The aim of this course is to introduce financial mathematics through various models and to study the various aspects of financial mathematics. The students will be enabled to understand the application of mathematics to solve the problems in the field of finance.

b. **Prerequisite Courses**:

Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:

Project Management
Financial Management

d. **Course Educational Objectives**:

The students would have a clear perception of the power of mathematical ideas and tools and would be able to demonstrate the application of mathematics to problems drawn from industry and financial services.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Grasp the concepts of random variables and expected values	K3
CO2	Learn present value analysis	K3
CO3	Understand Black-Scholes formula	K3
CO4	Appreciate the portfolio section problem	K3
CO5	Know exotic options	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**				**M**					**M**	**M**
CO2	**H**	**H**				**M**					**M**	**M**
CO3	**H**	**H**				**M**					**M**	**M**
CO4	**H**	**H**				**M**					**M**	**M**
CO5	**H**	**H**				**M**					**M**	**M**

H – High; M – Medium; L – Low

g. Course Content

Unit-I Probability and random variables

Probability and Events - Conditional probability - Random Variables and Expected values Covariance and Correlation - Normal Random Variables - Properties of Normal Random Variables.

Unit-II Present value analysis and arbitrage

Interest rates - Present value analysis - Rate of return - Continuously varying interest rates - Pricing contracts via Arbitrage.

Unit-III Arbitrage theorem and Black-Scholes formula

The Arbitrage theorem – Multi-period binomial model - Black-Scholes formula - Properties of Black Scholes option cost - Delta Hedging Arbitrage Strategy.

Unit-IV Expected utility

Limitations of arbitrage pricing - Valuing investments by expected utility - The portfolio section problem - Capital assets pricing model - Rates of return - Single period and geometric Brownian motion.

Unit-V Exotic options

Barrier options - Asian and look back options - Monte Carlo Simulation - Pricing exotic option by simulation.

h. Learning Resources

i. Text book

S.M. Ross, An Elementary Introduction to Mathematical Finance, 3rd Edition, Cambridge University Press, **2011**.

ii. Reference books:

1. M.Capiski and T.Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer Verlag, New York, **2003.**
2. H. F ̈ollmer and A. Schied, Stochastic Finance: An Introduction in Discrete Time, de Gruyter, **2011.**
3. J. Jacod, P. Protter, Probability Essentials, Universitext, Springer-Verlag, **2003**.
4. D. Lamberton, B. Lapeyre, Introduction to Stochastic Calculus Applied to Finance, Chapman-Hall, **2008.**
5. S.Roman, Introduction to the Mathematics of Finance, Springer International Edition, New York**, 2004**.
6. R.J.Williams, Introduction to the Mathematics of Finance, AMS, Universities Press (India) Pvt. Ltd, **2006**.

iii. **Online Resources**

1. https://pdfs.semanticscholar.org/b942/9568fbf11041ee277bcacf3be91b817848ba.pdf
2. https://euclid.ucc.ie/hanzon/MA4403_MS3019/[Sheldon_M._Ross]_An_Elementary_Introd_to_Mathfi(2).pdf
3. https://www.ethz.ch/content/dam/ethz/special-interest/mavt/dynamic-systems-n-control/idsc-dam/Lectures/Stochastic-Systems/Script_Stochastic_Sytems.pdf
4. https://www.stat.pitt.edu › stoffer › tsa3 › intro_prob
5. https://www.stat.auckland.ac.nz › ~fewster › notes
6. https://imai.fas.harvard.edu › teaching › files › Expectation
7. https://en.wikipedia.org › wiki › Black–Scholes_model
8. www.columbia.edu › QRM › DerivativesReview
9. www.maths.usyd.edu.au › MATH3075_3975_Course_Notes_2016
10. fsfsdfwww.zhufumin.com › wp-content › uploads › 2013/11 › Financial-asset-pri...

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60193MA201	**C + + PROGRAMMING**	**1**	**0**	**2**	**2**

Course Category: INSTITUTE ELECTIVE (INTEGRATED COURSE)

a. Preamble

This course seeks to introduce to the students the basics of C+ + Programming so as to
Improve logical thinking
Acquire skill in programming techniques
Learn a programming language that is well suited for Mathematical problems

b. Prerequisite Courses:

Mathematics as a Main Subject or Allied Subject in UG Level

c. Related Courses:

Programming Language

d. Course Educational Objectives:

To enable students to design and write computer programs that are correct, simple, clear, efficient, well organized, and well documented.
To enable students to apply programming skills in the areas of pure, applied mathematics and related areas.
The students will understand the hardware and software aspects of computer systems that support application software.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Know the concepts of Object Oriented Programming	K3
CO2	Learn constructors and destructors	K3
CO3	Understand the concept of inheritance	K3
CO4	Develop the skill in exception handling	K3
CO5	Appreciate virtual functions	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**									**M**
CO2	**H**	**H**	**M**									**M**
CO3	**H**	**H**	**M**									**M**
CO4	**H**	**H**	**M**									**M**
CO5	**H**	**H**	**M**									**M**

H – High; M – Medium; L - Low

g. Course Content

Unit- I Course Content:

UNIT I Basic concepts of Object Oriented Programming:

Object Oriented Programming Concepts – Objects – Classes – Methods And Messages – Abstraction and Encapsulation – Inheritance – Abstract Classes – Polymorphism - Applications of OOP - Introduction to C++ – Classes – Access Specifiers – Function and Data Members – Default Arguments – Function Overloading – Friend Functions – Static Members – Objects – Nested Classes

UNIT II Constructors

Constructors – Default constructor – Parameterized constructors – Constructor with dynamic allocation – Copy constructor – Destructors – Operator overloading – Unary operator overloading – Binary operator overloading - Overloading the assignment operator

UNIT III Inheritance

Inheritance – public, private, and protected derivations – Multiple Inheritance - Virtual Base Class – Abstract Class

UNIT IV Exception handling

Exception handling – Try-Catch-Throw paradigm – Exception Specification – Terminate and Unexpected Functions – Uncaught Exception.

UNIT V Virtual functions

Runtime polymorphism – virtual functions – pure virtual functions – I/O operations – Formatted I/O operations – Unformatted I/O operations – Manipulators - File handling.

h. Learning Resources

i. Text book:

B. Trivedi, Programming with ANSI C++, Oxford University Press, **2012**

ii. Reference books:

1. Goran Svenk, Object-oriented Programming: Using C++ for Engineering and Technology, 2nd Edition, **2003.**

2. Balagurusamy, Object-oriented Programming with C++, 4th Edition, Tata McGraw-Hill Education, **2008**

3. I.Pohl, Object Oriented Programming using C++, 2nd Edition, Pearson Education, **2004.**

4 B. Lippman, J.Lajoie, B.E. Moo, C++ Primer, 4th Edition, Pearson Education, **2005.**

iii. **Online Resources:**

1. https://www.programmingsimplified.com/cpp/source-code/fibonacci-series
2. https://www.programiz.com/cpp-programming/examples/fibonacci-series
3. https://www.tutorialspoint.com/cplusplus-program-to-display-fibonacci-series
4. https://www.programiz.com/cpp-programming/examples/factorial
5. https://www.tutorialspoint.com/cplusplus-program-to-find-factorial
6. www.cplusplus.com
7. www.cplusplus.com/doc/tutorial
8. https://www.geeksforgeeks.org/c-plus-plus/
9. https://www.codecademy.com/learn/learn-c-plus-plus

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60193MA202	**NUMERICAL METHODS USING C + +**	**1**	**0**	**2**	**2**

Course Category: INSTITUTE ELECTIVE (INTEGRATED COURSE)

a. Preamble

This Course seeks to develop the computational shill of the students.

b. Prerequisite Courses:

Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:

Computations using MATLAB

d. **Course Educational Objectives**:

The students will be able to understand, analyze and numerically solve various problems arising in Science and Engineering.

The students will be able to understand, analyze and numerically solve various problems arising in Science and Engineering.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Solve an algebraic equation numerically	K3
CO2	Find the numerical solution of a system of equations	K3
CO3	Determine the largest eigenvalue of a square matrix	K3
CO4	Find the interpolated values of a function	K3
CO5	Evaluate an integral and solve an O.D.E	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**									**M**
CO2	**H**	**H**	**M**									**M**
CO3	**H**	**H**	**M**									**M**
CO4	**H**	**H**	**M**									**M**
CO5	**H**	**H**	**M**									**M**

H – High; M – Medium; L - Low

i. Course Content

C++ PROGRAMS for the following numerical problems

UNIT – I Solutions of algebraic and transcendental equations

1. Program for bisection method
2. Program for secant method
3. Program for iteration method

UNIT – II Solutions of equations

4. Program to solve a system of linear equations using Gauss elimination method
5. Program to solve a system of linear equations using Gauss Jordan method
6. Program to solve a system of linear equations using Gauss Jacobi method

UNIT – III System of linear equations and power method

7. Program to solve a system of linear equations using Gauss Seidel method
8. Program to factorize matrix using LU decomposition method
9. For a given matrix, find the eigenvalue and eigenvector using Power Method

UNIT – IV Newton's and Lagrange's methods

10. Newton's Forward and Backward Difference Method
11. Newton's Divided Difference Method
12. Lagrange's interpolation method

UNIT – V Integration and ODE

13. Trapezoidal Rule
14. Simpson 1/3 and 3/8 Rules
15. Program to solve an ordinary differential equation

j. Learning Resources:

g. Text Book:

P.Gosh, Numerical Methods with Computer Programs in C + +, Prentice Hall of India Private Limited, New Delhi, **2009.**

ii. Reference Book:

1. J.Cortadella, Introduction to Programming in C + +, Numerical Method.
2. Rudra Pratap, Getting Started with MATLAB, Oxford University Press, 2016.

iii. **Online Resources:**

1. https://qmplus.qmul.ac.uk/course/view.php?id=8742
2. https://www.codewithc.com/category/numerical-methods/numerical-methods-c/
3. https://www.codingalpha.com/numerical-methods-c-program/
4. http://www.sci.brooklyn.cuny.edu/~mate/nml/numanal.pdf
5. http://www.cs.upc.edu/~jordicf/Teaching/programming/pdf/MATH01_Various.pdf
6. https://www.programming-techniques.com/2013/12/numerical-methods-tutorials.html.

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60193MA203	**MATHEMATICAL COMPUTING USING MATLAB**	**1**	**0**	**2**	**2**

Course Category: INSTITUTE ELECTIVE (INTEGRATED COURSE)

a. Preamble

The course seeks to develop the computational skill of the students.

b. Prerequisite Courses:

Mathematics as a Main Subject or Allied Subject in UG Level

c. **Related Courses**:

Programming with C+ +

d. **Course Educational Objectives**:

Students will be capable of handling any mathematical techniques using MATLAB.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Understand the important commands in MATLAB	K3
CO2	Know the basic ideas of Mathematics	K3
CO3	Learn the applications of MATLAB	K3
CO4	Understand the applications of MATLAB	K3
CO5	Understand the applications of MATLAB	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**									**M**
CO2	**H**	**H**	**M**									**M**
CO3	**H**	**H**	**M**									**M**
CO4	**H**	**H**	**M**									**M**
CO5	**H**	**H**	**M**									**M**

H – High; M – Medium; L - Low

g. Course Content

Unit - I: **Program structures**

The MATLAB environment, basic commands, data types, variables, Assignment statement, mathematical operators, Managing workspace, Handling of Arrays, Matrix operations and analysis, program structures - if statement, for loop, while loop, break statement , Creating-saving and running m-files, Functions based on arguments, Nested functions, File I/O handling, Debugging techniques.

Unit - II: **Applications of MATLAB in Mathematics**

Elementary Mathematics - Trigonometry, exponentials ,logarithms, rounding, remainders, descriptive statistics, Polynomials, Data visualization - 2D and 3D plotting, Random number generation, Integration, Double Integration, Differentiation, Partial Differentiation, Matrix Operations, Linear Equations, Eigen values and Eigen vectors, Matrix Analysis.

UNIT – III System of linear equations and power method

Program to solve a system of linear equations using Gauss Seidel method, factorize matrix using LU decomposition method, For a given matrix, find the eigenvalue and eigenvector using Power Method.

UNIT – IV Interpolations

Newton's Forward and Backward Difference Method, Newton's Divided Difference Method, Lagrange's interpolation method.

UNIT – V Integration and ODE

Trapezoidal Rule, Simpson 1/3 and 3/8 Method, solve an ordinary differential equation.

h. Learning Resources

i. Text Books:

1. S. Attaway. MATLAB: A Practical Introduction to Programming and Problem Solving, 3rd Edition , Elsevier , Butterworth Heinemann Publication.
2. W. J Palm III, Introduction to MATLAB 7 for Engineers, McGraw Hill, **2005**.

ii. Reference books:

1. D.Baez-Lopez, MATLAB with Applications to Engineering, Physics and Finance, CRC Press, **2010**.
2. A.K.Tyagi, MATLAB and Simulink for Engineers, 5th Impression, Oxford University Press, New Delhi, **2015**
3. D.Xue and Y. Chen, Solving Applied Mathematical Problems with MATLAB, CRC Press, **2008**.

iii. **Online Resources**:

1. https://in.mathworks.com/discovery/matlab-vs-r.html
2. https://nptel.ac.in/courses/103106118/2
3. http://www.dm.unibo.it/~piccolom/didattica/num_met/SAmatlab_09.pdf
4. https://www.mccormick.northwestern.edu/documents/students/undergraduate/introduction-to-matlab.pdf
5. https://web.stanford.edu/class/ee254/software/using_ml.pdf
6. https://www.mccormick.northwestern.edu/documents/students/undergraduate/introduction-to-matlab.pdf
7. http://www.ecaa.ntu.edu.tw/weifang/eBook/matlab-tutor.pdf

COURSE CODE	COURSE TITLE	L	T	P	C
60193MA204	MATHEMATICAL COMPUTING USING R	1	0	2	2

Course Category: INSTITUTE ELECTIVE (INTEGRATED COURSE)

a. Preamble

This course seeks to develop the computational skill of the students.

b. Prerequisite Courses:

Nil

c. **Related Courses**:
Computing Using MATLAB

d. **Course Educational Objectives**: Students will be capable of handling any mathematical techniques using R.

e. **Course Outcomes:**
After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Know the fundamental commands in R	K2
CO2	Learn the techniques of diagrammatic representation of data	K2
CO3	Know the measures of central tendency and dispersion	K2
CO4	Understand the use of R in testing of hypotheses	K3
CO5	Know the Applications of R in ANOVA and Design Theory	K3

f. **Correlation of Cos with POs**

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**									**M**
CO2	**H**	**H**	**M**									**M**
CO3	**H**	**H**	**M**									**M**
CO4	**H**	**H**	**M**									**M**
CO5	**H**	**H**	**M**									**M**

H – High; M – Medium; L - Low

g. Course Content

Unit - I: Basic commands in R

Overview of R Environment – R editor – Workspace – Data type in R – Matrix Operations - Importing and Exporting Dataset from Flat files – Combining datasets using cbind and Rbind – Variable creation using mathematical operator – Variable creation using conditional statement, For loop, While Loop.

Unit - II: Diagrammatical representation of Data

Sorting dataset – Drawing random sample – Statistical measures – Box plot, Stem and Leaf Diagram, Probability plot, Histogram and Pie Chart, scatter diagram.

Unit - III: Applications of R in Statistical Measures

Measure of central tendency, Measure of dispersion, Measure of Skewness and Measure of kurtosis, correlation with examples.

Unit - IV: Testing of Hypotheses

Tests of Hypotheses for a Single Sample and Statistical Inference for Two Samples Chi-square test.

Unit - V: Applications of R in ANOVA and Design Theory

ANOVA for real dataset for Completely Randomized Design, Randomized Block Design, Latin Square Design.

h. Learning Resources

i. Text Books:

1. R..Schumacker, Learning Statistics using R, Sage Publication, **2015**.
2. J.P.Lander, R for Everyone, Pearson Education, **2014**.

ii. Reference books:

1. N.Matloff, The Art of R Programming, No Starch Press, Inc., **2011**.

iii. **Online Resources**:

1. https://kingaa.github.io/R_Tutorial/
2. https://cran.r-project.org/doc/manuals/R-intro.html
3. https://www.oregon.gov/ODOT/Planning/Documents/R-Manual.pdf
4. https://cran.r-project.org/doc/contrib/Rossiter-RIntro-ITC.pdf
5. https://www.pearson.com/content/dam/one-dot-com/one-dot-com/us/en/files/LeslieChandrakantha-CTCM2018Paper-Chandrakantha.pdf
6. http://www2.ims.nus.edu.sg/preprints/2006-34.pdf