

## M.Sc. MATHEMATICS

2020 batch

Sem.	Course Code	Course Title	Course Type	Hrs./Wk.		Credits
				Theory	Lab	
I	PGM1501CM	ALGEBRA I	TH	6		5
	PGM1502CM	REAL ANALYSIS	TH	6		5
	PGM1402CM	ORDINARY DIFFERENTIAL	TH	5		4
	*	EQUATIONS				
	PGM1505CM	MATHEMATICAL STATISTICS	TH	6		5
	PGM1403CM	CALCULUS OF VARIATIONS AND	TH	5		4
		INTEGRAL EQUATIONS				
	PGV1001PV	FOUNDATION COURSE ON	TH	2		-
		WOMEN'S STUDIES				
	PGV1002PV	PERSPECTIVES ON GENDER				
	PIV1002PI	THE BIBLE AND SCIENCE				
		TOTAL		30		23
II	PGM2401CM	ALGEBRA II	TH	5		4
	*					
	PGM2402CM	MEASURE AND INT	TH	5		4
		EGRATION				
	PGM2403CM	TOPOLOGY	TH	5		4
	PGM2401MO	PARTIAL DIFFERENTIAL	TH	5		4
	* /	EQUATIONS / NUMERICAL				
		ANALYSIS				
	PGM2402MO	CLASSICAL MECHANICS				
	/					
	PGM2403MO					
	PGM2301CT	RESEARCH METHODOLOGY	LT	2	2	3

PGM2201EI */	ANALYTICAL SKILLS FOR COMPETITIVE EXAMINATIONS/ DISCRETE MATHEMATICS	T	4	2
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PGM2202EI \*

PGV2001PV	HUMAN RIGHTS AND DUTIES	TH	2	-
PGV2002PV	PRACTICING HUMAN RIGHTS			
PIV2002PI	RIGHTS, RESPONSIBILITIES AND THE BIBLE			
	TOTAL		30	21

Sem.	Course Code	Course Title	Course Type	Hrs./Wk.		Credits
				TH	LA	
III	PGM3401CM	DIFFERENTIAL GEOMETRY	TH	5		4
	PGM3402CM	COMPLEX ANALYSIS	TH	5		4
	PGM3403CM	GRAPH THEORY	TH	5		4
	PGM3404CM	COMBINATORIAL THEORY	TH	5		4
	PGM3401MO /	FLUID DYNAMICS/				
	PGM3402MO	OPERATIONS RESEARCH	TH	5		4
	PGM3201EI	ANALYTICAL SKILLS FOR COMPETITIVE EXAMINATIONS	TH	4		2
	PGM3202EI	FUZZY SETS AND ITS APPLICATIONS				
	PGV3001PV	BASIC TENETS OF MAJOR RELIGIONS				
	PGV3002PV	CULTURAL HERITAGE AND VALUES IN INDIA		1		-
	PGV3003PV	PROFESSIONAL ETHICS				

	<b>PIV3001PI</b>	<b>BIBLICAL ETHICS</b>			
			<b>TOTAL</b>	<b>30</b>	<b>22</b>
	<b>PGM4502CM</b>	<b>MODULE THEORY</b>	<b>TH</b>	<b>6</b>	<b>5</b>
	<b>PGM4503CM</b>	<b>FUNCTIONAL ANALYSIS</b>	<b>TH</b>	<b>6</b>	<b>5</b>
	<b>PGM4501CM</b>	<b>STOCHASTIC PROCESSES</b>	<b>TH</b>	<b>6</b>	<b>5</b>
	<b>PGM4504CM</b>	<b>NUMBER THEORY</b>	<b>TH</b>	<b>5</b>	<b>5</b>
	<b>PGM 0401PR</b>	<b>PROJECT</b>		<b>5</b>	<b>4</b>
<b>IV</b>	<b>PGV4001PV</b>	<b>UNIVERSAL VALUES</b>			
	<b>PGV4002PV</b>	<b>PEACE STUDIES AND PEACE MAKERS</b>			
	<b>PGV4003PV</b>	<b>IN TUNE WITH NATURE</b>	<b>TH</b>	<b>2</b>	<b>-</b>
	<b>PIV4001PI</b>	<b>BIBLICAL PERSPECTIVES ON GENDER</b>			
	<b>TOTAL</b>			<b>30</b>	<b>24</b>

# PGM1501CM ALGEBRA I

## (THEORY)

### COURSE OUTCOMES:

6 hrs./wk.

On successful completion of the course, the student will be able to

**CO1:** analyze the properties of groups and prove related results

**CO2:** analyze different concepts to prove related theorems

**CO3:** explain the properties and prove results on solvable groups

**CO4:** solve problems and prove theorems in Euclidean rings

**CO5:** construct polynomial rings over commutative fields and prove related concepts via theorem

### COURSE CONTENT:

#### UNIT I: GROUPS AND HOMOMORPHISMS

20 hrs.

Definition of a group – some examples of groups – some preliminary lemmas – subgroups – a counting principle – normal subgroups and quotient groups – homomorphisms – automorphisms.

#### UNIT II: SYLOW'S THEOREM AND FINITE ABELIAN GROUPS

20 hrs.

Cayley's theorem – permutation groups – another counting principle – Sylow's theorem – direct product – finite abelian groups

#### UNIT III: SOLVABLE GROUPS

15 hrs.

Generators of a subgroup and derived subgroups – normal series – solvable groups and Jordan Holder theorem.

#### UNIT IV: RING THEORY

15 hrs.

Euclidean rings – a particular Euclidean ring.

#### UNIT V: POLYNOMIAL RINGS

20 hrs.

Polynomials over the rational field – polynomial rings over commutative rings.

### TEXTBOOK(S):

Herstein I.N., (2002). *Topics in algebra*, (2<sup>nd</sup> ed.), Singapore: Wiley Eastern Limited. Print.(Chapters 2,3(3.7–3.11))

Surjeet Singh & Qazi Zameeruddin, (2001). *Modern algebra*, New Delhi: Vikas Publishing House Pvt. Limited. Print. (Chapter 5)

### REFERENCE BOOK(S):

David S Dummit & Richard M Foote, (2011). *Abstract Algebra*, (3<sup>rd</sup> ed.), New Jersey: John Wiley & Sons, Inc. Print. Publication

Jacobson, (1953). *Lectures in abstract algebra*, (Vol. I), New Delhi: Narosa Publishing House. Print.

John Fraleigh, (1982). *A first course in abstract algebra*, New Delhi: Narosa Publishing House. Print.

## **PGM1502CM REAL ANALYSIS**

(THEORY)

### **COURSE OUTCOMES:**

**6 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** identify the behaviour of series and prove results

**CO2:** examine and analyse the continuity of functions in different domains

**CO3:** prove theorems on differentiation and solve related problems

**CO4:** analyze the properties of Riemann – Stieltjes integral and to solve problems

**CO5:** discuss the pointwise and uniform convergence of sequences and series of functions and prove related results via

theorems

### **COURSE CONTENT:**

#### **UNIT I: NUMERICAL SERIES**

**20 hrs.**

Series – series of nonnegative terms – number  $e$  – root and ratio tests – power series – summation by parts – absolute convergence – addition and multiplication of series – rearrangements.

#### **UNIT II: CONTINUITY**

**20 hrs.**

Limits of functions – continuous functions – continuity and compactness – continuity and connectedness – discontinuities – monotonic functions – infinite limits and limits at infinity.

#### **UNIT III: DIFFERENTIATION**

**15 hrs.**

Derivative of a real function – mean value theorems – continuity of derivatives – L' Hospital's rule – derivatives of

higher order – Taylor's theorem – differentiation of vector-valued functions.

#### **UNIT IV: RIEMANN–STIELTJES INTEGRAL**

**15 hrs.**

Definition and existence of the integral – properties of the integral – integration and differentiation – integration of vector-valued functions.

#### **UNIT V: SEQUENCES AND SERIES OF FUNCTIONS**

**20 hrs.**

Discussion of main problem – uniform convergence – uniform convergence and continuity – uniform convergence and integration – uniform convergence and differentiation – equicontinuous families of functions – Stone Weierstrass theorem.

**TEXTBOOK(S):**

Walter Rudin, (2013). *Principles of Mathematical Analysis*, (3<sup>rd</sup> ed.), New Delhi: McGraw Hill Education (India) Private Limited. Print. (Chapters 3 (3.21 – 3.55), 4,5,6 (up to 6.25), 7)

**REFERENCE BOOK(S):**

Apostol, (1990). *Mathematical Analysis*. New Delhi: Narosa Publishing House, Print.

Karunakaran V., (2012). *Real Analysis*, New Delhi: Dorling Kindersley Pvt. Ltd., Print.

Richard R. Goldberg, (2012). *Methods of Real Analysis*, New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., Print.

**PGM1402CM ORDINARY DIFFERENTIAL EQUATIONS**

**(THEORY)**

**COURSE OUTCOMES:**

**5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** solve the first order homogeneous and non-homogeneous differential equations with constant coefficients

**CO2:** determine the solutions of second order linear differential equations with constant coefficients

**CO3:** evaluate the solutions of  $n^{\text{th}}$  order linear differential equations with constant coefficients and real constants

**CO4:** solve the first order homogeneous and non-homogeneous differential equations with variable coefficients

**CO5:** test the existence and uniqueness of solutions of first order differential equations and solve them using various methods

**COURSE CONTENT:**

**UNIT I: FIRST ORDER LINEAR EQUATIONS WITH CONSTANT COEFFICIENTS**

**15 hrs.**

Differential equations – problems associated with differential equations – linear equations of the first order – equation  $y' + ay = 0$  – equation  $y' + ay = b(x)$  – general linear equation of the first order.

**UNIT II: SECOND ORDER LINEAR EQUATIONS WITH CONSTANT COEFFICIENTS** 15 hrs.

Second order homogeneous equations – initial value problems – linear dependence and independence – a formula for Wronskian – non-homogeneous equation of order two.

**UNIT III: HIGHER ORDER LINEAR EQUATIONS WITH CONSTANT COEFFICIENTS** 15 hrs.

Homogeneous and non-homogeneous equations of order  $n$  – initial value problems for  $n^{\text{th}}$  order equations – equations with real constants.

**UNIT IV: LINEAR EQUATION WITH VARIABLE COEFFICIENTS** 15 hrs.

Initial value problems for the homogeneous equation – solutions of the homogeneous equation – the Wronskian and linear independence – reduction of the order of a homogeneous equation – non-homogeneous equation – homogeneous equations with analytic coefficients.

**UNIT V: EXISTENCE AND UNIQUENESS OF SOLUTIONS TO FIRST ORDER EQUATIONS** 15 hrs.

Equations with variables separated – exact equations – method of successive approximations – Lipschitz condition.

**TEXTBOOK(S):**

Earl.A. Coddington, (2003). *An Introduction to Ordinary Differential Equations*, New Delhi: Prentice Hall of India Ltd. Print. (Chapters 1,2(1 – 10), 3(1 – 7), 5 (1 – 5)).

**REFERENCE BOOK(S):**

Frank Ayres Jr, (2000). *Differential Equations*. Singapore:Schaum outline series, McGraw Hill Company. Print.

Garrett Birkoff& Gian Carlo Rota, (1989). *Ordinary Differential Equation*,(3<sup>rd</sup> ed.), New York: John Wiley. Print.

**PGM1505CM MATHEMATICAL STATISTICS**

**(THEORY)**

**COURSE OUTCOMES:**

**6hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** identify the distribution of a random variable and calculate its expected values and related terms

**CO2:** determine the marginal and conditional distributions of two random variables and expectations and variances of random variables and prove related results

**CO3:** apply discrete and continuous probability distributions to solve problems

**CO4:**find the probability density functions, mean and variance of continuous distributions and the distribution function of  $r^{\text{th}}$  order statistic

**CO5:**examine the convergence in probability and in distribution of a random variable with cumulative density function and prove related theorems

**COURSE CONTENT:**

**UNIT I: PROBABILITY AND DISTRIBUTION** **21 hrs.**

Random variables – discrete random variables – continuous random variables – transformations – expectation of a random variable – some special expectations – important inequalities.

**Self-Study:** Problem solving

**UNIT II: MULTIVARIATE DISTRIBUTIONS** **20 hrs.**

Distributions of two random variables – expectation – transformations: bivariate random variables – conditional distributions and expectations – correlation coefficient – independent random variables – extension to several random variables –transformations for several random variables – linear combinations of random variables.

**Self-Study:**Problem solving

**UNIT III: DISTRIBUTIONS** **20 hrs.**

Binomial and related distributions – Poisson distribution – Gamma, Chi-square and Beta distributions – Normal distribution.

**Self-Study:** Problem solving

**UNIT IV: SPECIAL DISTRIBUTIONS AND ORDER STATISTICS** **14 hrs.**

t and F distributions – order statistics.

**Self-Study:** Problem solving

**UNIT V:CONSISTENCY AND LIMITING DISTRIBUTIONS** **15 hrs.**

Convergence in probability – convergence in distribution.

**Self-Study:** Problem solving

**TEXTBOOK(S):**

Robert V. Hogg, Joseph Mckean & Allen T. Craig, (2018). *Introduction to Mathematical Statistics*, (7<sup>th</sup> ed.), New York: Macmillan Publishing Company. Print. (Chapter 1(32– 69), 2 (75 – 124, 128-139), 3 (141 – 180, 191–198), 4 (231 –234, 240, 241), 5 (295 – 305)).

**REFERENCE BOOK(S):**

John E. Freund, (1998). *Mathematical Statistics*, (6<sup>th</sup> ed.), New Delhi: Prentice Hall of India Private Limited. Print.

Jun Shao., (1999). *Mathematical Statistics*, (2<sup>nd</sup> ed.), USA: Springer-Verlag. Print.

Parimal Mukhopadhyay, (2016). *Mathematical Statistics*, Kolkata: Books and Allied Pvt.Ltd.  
Print.

**PGM2401CM ALGEBRA II**  
**(THEORY)**

**COURSE OUTCOMES:** **5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** interpret the algebraic structure of extension fields and the transcendence of  $e$  via theorems

**CO2:** analyse the roots of polynomials via theorem

**CO3:** explain the elements of Galois theory and to prove related results

**CO4:** categorize the linear transformations

**CO5:** apply the properties of linear transformations to prove theorems

**COURSE CONTENT**

**UNIT I: EXTENSION FIELD** **15 hrs.**

Extension fields—the transcendence of  $e$

**UNIT II: ROOTS OF POLYNOMIALS** **15 hrs.**

Roots of polynomials –more about roots

**UNIT III: GALOIS THEORY** **15 hrs.**

The elements of Galois theory.

**UNIT IV: LINEAR TRANSFORMATIONS** **15 hrs.**

Canonical forms: Triangular form – nilpotent transformations – Jordan and rational canonical forms

**UNIT V: PROPERTIES OF LINEAR TRANSFORMATIONS** **15 hrs.**

Trace and transpose – Hermitian– unitary and normal transformations – real quadratic forms

**TEXTBOOK(S):**

Herstein I.N., (2014). *Topics in Algebra*, (2<sup>nd</sup> edition), Singapore: John Wiley & Sons.  
Print.(Chapter: 5 (5.1 – 5.3, 5.5–5.6), 6 (6.4–6.8, 6.10 –6.11)).

**REFERENCE BOOK(S):**

Jacobson., (1973). *Basic Algebra*, Delhi: Hindustan publishing corporation. Print.

Kaplansky., (1969). *Fields and Rings*, Chicago: University of Chicago press. Print.

Serge Lange, (1984). *Algebra*, London: Wesley publishers. Print.

Vijay K Khanna, Bhambri S.K., (2018). *A course in abstract algebra*, (5<sup>th</sup> ed.), New Delhi: Vikas Publishing House

**PGM2402CM MEASURE AND INTEGRATION**  
**(THEORY)**

**COURSE OUTCOMES:**

**5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:**examine the Lebesgue measurability of a given set and prove theorems

**CO2:**explain the concepts and theorems of measurable functions

**CO3:**discuss the properties of Lebesgue integrals of bounded, non-negative and measurable functions via theorems

**CO4:**explain the types of measures and their properties

**CO5:** extend the concepts of outer measure to general measure

**COURSE CONTENT:**

**UNIT I: LEBESGUE MEASURE**

**18 hrs.**

Lebesgue outer measure –  $\sigma$ -algebra of Lebesgue measurable sets – outer and inner approximation of Lebesgue measurable sets – countable additivity– continuity– the Borel-Cantelli lemma – non-measurable sets –Cantor set and the Cantor – Lebesgue function.

**UNIT II: LEBESGUE MEASURABLE FUNCTIONS**

**15 hrs.**

Sums, products and compositions – sequential pointwise limits and simple approximation – Littlewood's three Principles – Egoroff's theorem – Lusin's theorem

**UNIT III: LEBESGUE INTEGRATION**

**18 hrs.**

The Riemann integral – Lebesgue integral of a bounded measurable function over a set of finite measure – Lebesgue integral of a measurable nonnegative function –general Lebesgue integral – countable additivity and continuity of integration.

**UNIT IV: GENERAL MEASURE SPACES**

**12 hrs.**

Measures and measurable sets – signed measures: Hahn and Jordan Decompositions – Caratheodory measure induced by an outer measure.

**UNIT V: INTEGRATION OVER GENERAL MEASURE SPACES**

**12 hrs.**

Measurable functions – integration of nonnegative measurable functions – integration of general measurable functions.

**TEXTBOOK(S):**

Royden H.L., Fitzpatrick P.M., (2013). *Real Analysis*, (4<sup>th</sup> ed.), Delhi: PHI Learning Pvt. Ltd. Print. (Chapter 2,3,4(4.1 – 4.5),17(17.1-17.3),18(18.1-18.3(up to Lebesgue Dominated Convergence Theorem))

**REFERENCE BOOK(S):**

De Barra, (2006). *Measure Theory and Integration*, New Delhi: New Age International limited. Print.

Halmos, (2000). *Measure Theory*, New Delhi: Narosa Publishing House. Print.

**PGM2403CM TOPOLOGY****(THEORY)****COURSE OUTCOMES:****5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:**find the limit points, interior and closure of a set in different topologies and prove related results

**CO2:**extend the concept of metrics to topological spaces and apply concepts of continuous functions on product

topology and metric topology

**CO3:**relate the connectedness and compactness of a topological space via different theorems

**CO4:** apply the concept of normal spaces to prove related theorems

**CO5:**construct the Stone-Cech compactification of a completely regular space and apply concepts to prove the

Tychonoff theorem

**COURSE CONTENT:****UNIT I: TOPOLOGICAL SPACES****15 hrs.**

Topological spaces – basis for a topology– order topology – product topology on  $X \times Y$ – subspace topology – closed sets and limit points.

**UNIT II: CONTINUOUS FUNCTIONS****15 hrs.**

Continuous functions – product topology – metric topology.

**UNIT III: CONNECTEDNESS AND COMPACTNESS****15 hrs.**

Connected spaces – connected subspaces of the real line –compact spaces– compact subspaces of the real line – limit point compactness

**UNIT IV: COUNTABILITY AND SEPARATION AXIOMS****15 hrs.**

Countability axioms (definitions only) – separation axioms– normal spaces –Urysohn lemma – Urysohn metrization theorem – Tietze extension theorem

**UNIT V: THE TYCHONOFF THEOREM****15 hrs.**

Tychonoff theorem – Stone-Cech compactification

**TEXTBOOK(S):**

James R. Munkres, (2011). *Topology*, (2<sup>nd</sup> ed.), New Delhi: PHI Learning Pvt Ltd. Print.  
(Chapter 2(12– 21), 3(23, 24 ,26 - 28), 4(30(definitions only), 31(only theorems), 32(only theorems), 33 to 35), 5(37,38).

**REFERENCE BOOK(S):**

Fred H. Croom., (2009). *Principles of Topology*, New Delhi: Cengage Learning India Pvt Ltd. Print.

Gupta B.D., (2015). *Topology*, New Delhi: Kedar Nath Ramanath Publishers. Vimal offset Printers. Print.

Malik A.K & Singh S.R., (2012). *Topology*, New Delhi: International Publishing House Pvt Ltd. Print.

## **PGM2301CT RESEARCH METHODOLOGY**

### **(LAB CUM THEORY)**

**COURSE OUTCOMES:**

**2T+2L hrs./wk.**

On completion of this course, the student will be able to

**CO1:** explain the meaning and significance of research

**CO2:** interpret the research problem

**CO3:** omit plagiarism while writing a report

**CO4:** make use of LaTeX code to prepare a project report

**CO5:** create a presentation using Beamer

**COURSE CONTENT:****UNIT I: MEANING OF RESEARCH AND RESEARCH DESIGN****10T hrs.**

Research methodology: Introduction – meaning of research – objectives of research – motivation in research – types of research – research approaches – significance of research – defining the research problem– selecting the problem – necessity of defining the problem – technique involved in defining a problem - research design – meaning of research design – need for research design - features of a good design

**UNIT II: INTERPRETATION****10T hrs.**

Interpretation and report writing – meaning of interpretation – significance of interpretation – technique of interpretation – precaution in interpretation.

**UNIT III: REPORT WRITING AND PLAGIARISM****10T hrs.**

Significance of report writing – different steps in writing report – layout of the research report – types of reports – oral presentation – Plagiarism–meaning of plagiarism – types of plagiarism – glossary – preventing plagiarism when writing.

**UNIT IV: INTRODUCTION TO LATEX** **15L hrs.**

Latex documentation preparing an input file – paragraphs – special symbols –mathematical formulae – defining commands and environments – type style

**UNIT V: PRESENTATION USING LATEX** **15L hrs.**

Cross reference – bibliography – preparing one’s own document – errors – bibliography database – preparing slides using Beamer.

**TEXTBOOK(S):**

Kothari C.R., (2012). *Research Methodology (Methods and Techniques)*, 2<sup>nd</sup> ed., New Delhi: New Age International Publishers. (UNITS I, II). Print.

Leslie Lamport, (2003). *A Document Preparation System LaTeX User’s Guide and Reference Manual*, New Delhi: Pearson Education. (UNIT IV, V). Print.

**WEBSITE**

<http://www.plagiarism.org/plagiarism-101/what-is-plagiarism/>(UNIT III)

**REFERENCE BOOK(S):**

Nambudiripad K. B. M. , (2014). *LaTeX for beginners*, New Delhi: Narosa Publishing House Pvt Ltd. Print.

Ranjit Kumar, (2011). *Research Methodology, A step-by step guide for beginners* (3<sup>rd</sup> ed.), London: Sage Publications, Print.

Santosh Gupta, (2005). *Research Methodology and Statistical Techniques*, New Delhi: Deep & Deep Publications, Print.

**PGM2401MO PARTIAL DIFFERENTIAL EQUATIONS**

**(THEORY)**

**COURSE OUTCOMES:** **5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** solve the first order linear and non-linear partial differential equations

**CO2:** discuss different methods of solving Partial Differential Equation

**CO3:** classify second order partial differential equation, solve problems of one-dimensional wave equations and

vibrations of strings

**CO4:** evaluate problems on strings

**CO5:**explain heat equation and wave equation

**COURSE CONTENT:**

**UNIT I: PARTIAL DIFFERENTIAL EQUATION OF THE FIRST ORDER** **15 hrs.**

Origin of first order partial differential equations – Cauchy’s problem – linear equations – integral surfaces passing through

a given curve – surfaces orthogonal to a given system of surfaces – non-linear partial differential equations

**UNIT II: PARTIAL DIFFERENTIAL EQUATION OF FIRST ORDER CONTINUED** **15 hrs.**

Cauchy’s method of characteristics – compatible systems of first order equations – Charpit’s method – special types of first order equations – solutions satisfying given conditions – Jacobi’s method.

**UNIT III: PARTIAL DIFFERENTIAL EQUATION OF SECOND ORDER** **15 hrs.**

Genesis of second order partial differential equation – classification of second order partial differential equation – one dimensional Wave Equation: vibrations of an infinite string – vibration of a semi-infinite string – vibration of a string of finite length (method of separation of variables).

**UNIT IV: PARTIAL DIFFERENTIAL EQUATION OF SECOND ORDER CONTINUED** **15 hrs.**

Riemann’s Method – vibrations of a string of finite length – Laplace’s equation – boundary value problems – maximum and minimum principles – the Cauchy Problems.

**UNIT V: HEAT CONDUCTION PROBLEM AND DUHAMEL’S PRINCIPLE** **15 hrs.**

Heat conduction problem – heat conduction infinite rod case – heat conduction finite rod case – Duhamel’s principle: wave equation – heat conduction equation.

**TEXTBOOK(S):**

Amaranath T., (2017). *An Elementary Course in Partial Differential Equations*, (2<sup>nd</sup> ed.), New Delhi: Narosa Publishing House. Print. (Chapter 2(2.1 – 2.3, 2.4(2.4.1 – 2.4.3), 2.5,2.6))

Sneddon Ian., (1988). *Elements of Partial Differential Equations*, (International students edition), Singapore: McGraw Hill Book & Co. Print. (Chapter 2(2. 1 – 2.13)).

**REFERENCE BOOK(S):**

Deo S.C. and Raghavendra V. (2002), *Ordinary differential equations and stability theory*, New Delhi; Tata McGraw Hill Publishing Company Limited. Print.

Dutta B.K, (1993). *An introduction to partial differential equations*, Calcutta: New Central Book Agency (P) Ltd. Print.

Garrett Birkoff and Gian – Carlo Rota., (1978). *Ordinary differential equations*, (3<sup>rd</sup> ed.), New York: John Wiley and sons. Print.

SankaraRaoK., (2004). *Introduction to partial differential equations*, New Delhi: Prentice hall of India Private Limited. Print.

## **PGM2402MO NUMERICAL ANALYSIS**

### **(THEORY)**

#### **COURSE OUTCOMES:**

**5hrs./wk.**

On Successful completion of this course, the student will be able to

**CO1:** evaluate the numerical solution of simultaneous equations by appropriate methods

**CO2:** find the eigen values and eigen vectors of matrices using different methods

**CO3:** evaluate the approximate value of the derivatives of a given function

**CO4:** apply different methods to find approximate solution of integral equations

**CO5:** solve first order ordinary differential equations numerically

#### **COURSE CONTENT:**

##### **UNIT I: SOLUTION OF SIMULTANEOUS LINEAR ALGEBRAIC EQUATION:**

**15 hrs.**

Gauss elimination method – Gauss-Jordan elimination method – method of triangular decomposition – Iteration methods of solving simultaneous equations – Jacobi iteration method – Gauss-Seidel iteration method.

##### **UNIT II: EIGEN VALUES**

**15 hrs.**

Eigen values and eigen vectors – Jacobi method for symmetric matrices – Givens method – Householder's method.

##### **UNIT III: NUMERICAL DIFFERENTIATION**

**15 hrs.**

Numerical differentiation – extrapolation methods – partial differentiation.

##### **Unit IV: NUMERICAL INTEGRATION**

**15 hrs.**

Methods based on undetermined coefficients – Gauss Quadrature methods – Gauss-Legendre integration methods – Gauss-Chebyshev integration methods.

##### **UNIT V: ORDINARY DIFFERENTIAL EQUATIONS**

**15 hrs.**

Singlestep methods – Taylor series method – Runge-Kutta methods: Explicit Runge-Kutta methods (second and fourth order methods only) (without truncation error)

#### **TEXTBOOK(S):**

Jain M.K., Iyengar S.R.K. & Jain R.K., (2003). *Numerical Methods for Scientific and Engineering Computation* (4<sup>th</sup> ed.), New Delhi: New Age International (P) limited Publishers.

Print. (Chapter 3: 3.2,3.4(pages 115 - 140,153-158), 3.5,3.7-3.9(pages 176 - 180,186-199), 5:5.2,5.4,5.5(pages 328 - 343,347-353), 5.8(pages 365 – 378), 6 (6.4) (pages 445 - 458)).

**REFERENCE BOOK(S):**

Jain., (2014). *Numerical solution of differential equations* (2<sup>nd</sup> ed)., New Delhi: New Age International (P) limited Publishers. Print.

Samuel D. Conte, Carl De Boor., (2005). *Elementary Numerical Analysis*, New York: McGraw-Hill International Edition. Print.

Curtis F. Gerald & Patrick O. Wheatley., (2003). *Applies Numerical Analysis*, New Delhi: Addison-Wesley Publishing Company Pearson Education.Print.

**PGM2403MO CLASSICAL MECHANICS  
(THEORY)**

**COURSE OUTCOMES:**

**5 hrs./ wk.**

On successful completion of the course, the student will be able to

**CO1:** apply the Newton's laws for a system of particles, explain the D'Alembert's principle and the concept of dissipation function

**CO2:** find the equation of motion of a mechanical system using Lagrangian and Hamiltonian formulations

**CO3:** classify the orbits of motion and reduce two body problem to an equivalent one body problem and prove related results

**CO4:** identify the central forces in closed orbits and prove related results

**CO5:** change the basis from one set of co-ordinates to another using the Legendre transformation

**COURSE CONTENT:**

**UNIT I: ELEMENTARY PRINCIPLES**

**15 hrs.**

Mechanics of a particle – Mechanics of a system of particles – constraints – D'Alembert's principle and Lagrange's equations – velocity–dependent potentials and dissipation function

**UNIT II: VARIATIONAL PRINCIPLES AND LAGRANGE'S EQUATIONS**

**15 hrs.**

Hamilton's principle – some techniques of the calculus of variations – derivation of Lagrange's equations from Hamilton's principle – extension of Hamilton's principle to nonholonomic systems

**UNIT III: ONE-BODY PROBLEM AND CLASSIFICATION OF ORBITS** **15 hrs.**

Reduction to the equivalent one – body problem – equations of motion and first integrals – equivalent one-dimensional problem and classification of orbits – virial theorem

**UNIT IV: THE TWO–BODY CENTRAL FORCE PROBLEM** **15 hrs.**

The differential equation for the orbit and integrable power–law potentials – conditions for closed orbits (Bertrand's theorem) – Kepler problem: Inverse square law of force

**UNIT V: THE HAMILTON EQUATIONS OF MOTION** **15 hrs.**

Legendre transformations and the Hamilton equations of motion – Cyclic coordinates and conservation theorems.

**TEXTBOOK(S):**

Herbert Goldstein, (2018). *Classical Mechanics*, (2<sup>nd</sup> ed.), New Delhi: Narosa Publishing House, Print. (Chapters: 1(1.1 – 1.5), 2(2.1 – 2.4), 3(3.1–3.7), 8(8.1,8.2))

**REFERENCE BOOK(S):**

Donald T. Greenwood, (2016). *Classical Dynamics*, New York: Dover Publications Inc. Print.

Gupta S.L., Kumar V. and Sharma H.V., (2017). *Classical Mechanics*, Meerut: Pragati Prakashan. Print.

John L. Synge and Byron A. Griffith, (1970). *Principles of Mechanics*, (3<sup>rd</sup> ed.), New Delhi: Tata Mc.Graw Hill Book Company Inc. Print.

## **PGM2202EI DISCRETE MATHEMATICS**

### **(THEORY)**

**COURSE OUTCOMES:** **4hrs./ wk.**

On successful completion of the course, the students will be able to

**CO1:** construct truth tables for compound statements and derive different formulae

**CO2:** modify a logical formula into different normal forms

**CO3:** solve problems in propositional calculus

**CO4:** find the adjacency matrix and prove related results

**CO5:** list the properties of a tree structure and solve problems

**COURSE CONTENT:**

**UNIT I: MATHEMATICAL LOGIC****12 hrs.**

Statements and notations – connectives – well-formed formulas – tautologies – equivalence of formulas – duality law – tautological implications – other connectives.

**UNIT II: NORMAL FORMS****12 hrs.**

Disjunctive normal forms – conjunctive normal forms – principal disjunctive normal forms – principal conjunctive normal forms.

**UNIT III: THEORY OF INFERENCE FOR THE STATEMENT CALCULUS****12 hrs.**

Validity using truth tables – rules of inference – consistency of premises and indirect method of proof.

**UNIT IV: INTRODUCTION TO GRAPHS****12 hrs.**

Basic concepts – isomorphism and subgraphs.

**UNIT V: TREES****12 hrs.**

Definition – properties of trees.

**TEXTBOOK(S):**

Mott J.L., Kandel A., Baker.T.P (2009).*Discrete maths for computer scientists & mathematicians*,(2<sup>nd</sup>ed.) New Delhi:Prentice Hall of India Pvt Limited. Print.(Chapter 5 : 5.1 to 5.3).

Tremblay J.P. and Manohar R.,(2005). *Discrete mathematical structures with applications to computer science*, (2<sup>nd</sup> ed.) NewDelhi: Tata McGraw Hill publishing company limited. Print. (Chapter 1:1.1,1.2(1.2.1 to 1.2.4 ,1.2.6 -1.2.11,1.2.14),1.3(1.3.1 to 1.3.4),1.4(1.4.1to1.4.3)).

**REFERENCE BOOK(S):**

Arumugam.S and Ramachandran S.,(2010).*Invitation to graph theory*, Chennai: Scitech publications private Limited. Print.

Chowdhary K.R.,(2012).*Fundamentals of discrete mathematical structures* (2<sup>nd</sup> ed.) ,New Delhi: PHI Learning Private Limited. Print.

Seymour Lipschutz and Mark Lipson.,(2010) .*Discrete mathematics*(third edition) ,New Delhi :Tata McGraw Hill publishing Co. Ltd .Print.

Venkataraman M.K., Sridharan N. and Chandrasekaran N.,(2001).*Discrete mathematics*, Chennai :The National publishing company. Print.

## PGM2201EI/PGM3201EI ANALYTICAL SKILLS FOR COMPETITIVE EXAMINATIONS

(THEORY)

**COURSE OUTCOMES:** 4 hrs./wk.

On successful completion of the course, the student will be able to

**CO1:** apply short-cut techniques to solve arithmetical problems

**CO2:** find the simple interest, compound interest, dividend, profit and loss

**CO3:** solve problems in mensuration with speed and accuracy

**CO 4:** interpret data represented graphically to solve problems

**CO 5:** analyze critically and find the solution of mathematical puzzles

**COURSE CONTENT:**

**UNIT I: ARITHMETICAL ABILITY** 12 hrs.

Averages – percentages – ratio and proportions – time and work – time and distance.

**UNIT II: BUSINESS MATHEMATICS** 12 hrs.

Simple interest – compound interest – stocks and shares – profit and loss.

**UNIT III: MENSURATION** 12 hrs.

Area – volume and surface areas.

**UNIT IV: DATA INTERPRETATION** 12 hrs.

Bar graphs – pie charts – line graphs.

**UNIT V: VERBAL AND NON-VERBAL REASONING** 12 hrs.

Logical reasoning – Mathematical puzzles.

**TEXTBOOK(S)**

Aggarwal R.S. (2015), *Quantitative Aptitude*, New Delhi :S. Chand & Company Pvt. Ltd. Print.  
(Chapter 6, 10, 11, 12, 15, 17, 21, 22, 24, 25, 29, 37, 38, 39).

Aggarwal R.S., (2015). *Modern approach to verbal and nonverbal reasoning*, New Delhi: S.  
Chand & company Pvt. Ltd. Print. (Part I – Section I: 5, 6, 8, Part II – 1, 5, 6)

**REFERENCE BOOK(S)**

Alok Kumar, (2008). *CSIR/UGCNET/JRF/SET Mathematics Sciences*, New Delhi:  
Upkar Prakashan. Print.

Edgar Thrope, (1989). *A course in mental ability and quantitative aptitude for competitive examinations*, New Delhi: Tata McGraw Hill Publishing Company Limited. Print.

## PGM 0201CD SPECIAL FUNCTIONS

### (THEORY)

#### COURSE OUTCOMES:

On successful completion of the course, the student will be able to

**CO1:** find the series solution of Legendre's differential equation and develop recurrence relations

**CO2:** analyze the properties of Bessel's equations

**CO3:** explain the principles of hyper geometric functions

**CO4:** determine the generating functions and recurrence relations of Hermite polynomials

**CO5:** discuss the generating functions and orthogonal properties of Chebyshev polynomials

#### COURSE CONTENT:

##### UNIT I:FROBENIOUS METHOD, LEGENDER EQUATIONS

Methods of integration in series – Frobenious method– Some simple problems – Legendre's differential equation – solutions  $P_n(x)$  and  $Q_n(x)$  – generating functions– orthogonal properties– recurrence formulae – Rodrigue's formula and Christoffel's expansion.

##### UNIT II: BESSEL'S EQUATIONS

Bessel's differential equation –  $J_n(x)$  – generating function – recurrence formulae – orthogonal properties.

##### UNIT III: HYPERGEOMETRIC FNCTIONS

Hypergeometric differential equation – properties – Kummer's theorem– Gauss theorem – differentiation of hypergeometric functions.

##### UNIT IV: HERMITE POLYNOMIALS

Hermite differential equation – Hermite polynomials – generating functions – recurrence formulae – orthogonal properties.

##### UNIT V: CHEBYSHEV POLYNOMIALS

Chebyshev differential equation – Chebyshev polynomials –  $T_n(x)$  and  $U_n(x)$  – generating function – orthogonal properties – recurrence formulae.

#### TEXTBOOK(S):

Gupta B.D., (2004). *Mathematical Physics*, (3<sup>rd</sup> ed.), New Delhi: Vikas publishing house private limited. Print.

(Chapter 8 (8.1 – 8.60), (8.73 – 8.87))

Sharma J.N. & Gupta R.K., (2000). *Special functions*, Meerut: Krishna prakashan media(P) Ltd. Print.

(Chapter 6, 8)

**REFERENCE BOOK(S):**

Gupta P.P., Malik G.S. & Mittal S.K., (2001). *Differential equations with partial differential equations and special functions*, (7<sup>th</sup>ed. revised), Meerut: Pragati Prakashan publication. Print.  
Sneddon I.N., (2012). *Special functions of mathematical physics and chemistry*, (3<sup>rd</sup> ed.), London: Longman group limited. Print.

**PGM3401CM DIFFERENTIAL GEOMETRY**

**(THEORY)**

**COURSE OUTCOMES:**

**5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** find the curvature and torsion of a curve and prove related results

**CO2:** make use of the concepts of developable surfaces, tangent and normal lines to prove related results

**CO3:** illustrate results in terms of curvilinear coordinates and fundamental magnitudes

**CO4:** develop proofs of different concepts on surfaces

**CO5:** prove results on geodesics and solve problems

**UNIT I: CURVES WITH TORSION**

**15 hrs.**

Tangent – principal normal – curvature – binormal – SerretFrenet formulae – locus of centre of curvature – spherical curvature – locus of centre of spherical curvature – curve determined by its intrinsic equations – helices – spherical indicatrix of tangent – involutes – evolutes – Bertrand curves.

**UNIT II: ENVELOPE, DEVELOPABLE SURFACES**

**15 hrs.**

Surfaces – tangent plane – normal – envelope – characteristics – edge of regression – developable surfaces – osculating developable – polar developable – rectifying developable – envelope – characteristic points.

**UNIT III: CURVILINEAR COORDINATES ON A SURFACE, FUNDAMENTAL MAGNITUDES**

**15 hrs.**

Curvilinear coordinates – first order magnitudes – directions on a surface – normal – second order magnitudes – derivatives of  $n$  – curvature of normal section – Meunier's theorem.

**UNIT IV: CURVES ON A SURFACES**

**15 hrs.**

Principal directions and curvatures – first and second curvatures – Euler’s theorem – surface  $z = f(x,y)$  – surface of revolution.

**UNIT V: GEODESICS AND GEODESIC PARALLELS**

**15 hrs.**

Geodesic property – equations of geodesics – surface of revolution – torsion of a geodesic – Bonnet’s theorem – Joachimthal’s theorem – vector curvature – geodesic curvature – Bonnet’s formula.

**TEXTBOOK(S):**

Weatherburn C.E., (2016). *Differential Geometry of three dimensions Vol. I*, UK: Cambridge University Press. Print. (Chapters 1 to 4(29 – 31, 33 – 34) , 6(46 – 55))

**REFERENCE BOOK(S):**

Gupta, Malik, Pundir S.K., (2015). *Differential Geometry*, Meerut:K.K.Mittal for Prakashan. Print.

Mittal S.C., Agarwal D.C., (2010). *Differential Geometry*, (36<sup>th</sup> ed.), Meerut: Krishna Prakashan Media (P) Ltd. Print.

Willmore T.J., (2012). *An Introduction to Differential Geometry*, USA: Courier Corporation. Print.

**WEBLINK(S):**

**eBook**

Muzammil Tanveer, (2020). *Differential Geometry*. Retrieved from

<https://www.mathcity.org/msc/notes/differential-geometry-syed-hassan-waqas>. CC BY -NC-SA 4.0

license.

Usman Hamid. M., (2019). *Differential Geometry*. Retrieved from

<https://www.mathcity.org/msc/notes/differential-geometry-m-usman-hamid>. CC BY -NC-SA 4.0 license.

**Video**

NP-TEL. (2014, August 12). *Vector Calculus in Geometry* [Video file]. Retrieved from

[https://www.youtube.com/watch?v=My\\_RCvKdHys&t=732s](https://www.youtube.com/watch?v=My_RCvKdHys&t=732s). CC BY license.

**PGM3402CM COMPLEX ANALYSIS**

**(THEORY)**

**COURSE OUTCOMES:**

**5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** prove results and solve problems on complex numbers and functions

**CO2:** apply conformal mappings and linear transformations in related areas

**CO3:** prove standard results on complex integration and evaluate line integrals

**CO4:** classify singularities, prove results and evaluate definite integrals

**CO5:** identify the behaviour of infinite series and infinite products and prove results

**COURSE CONTENT:**

**UNIT I: COMPLEX NUMBERS AND COMPLEX FUNCTIONS**

**15 hrs.**

Binomial equation – the spherical representation – limits and continuity – analytic functions – polynomials – rational functions – sequences and series – uniform convergence – power series – Abel's limit theorem.

**UNIT II: ANALYTIC FUNCTIONS AS MAPPINGS**

**15 hrs.**

Arcs and closed curves – analytic functions in regions – conformal mappings – length and area – cross ratio – symmetry – elementary conformal mappings.

**UNIT III: COMPLEX INTEGRATION**

**15 hrs.**

Line integrals – rectifiable curves – line integrals as functions of arcs – Cauchy's theorem for a rectangle – Cauchy's theorem for an open disc – index of a point with respect to a closed curve – Cauchy's integral formula – higher derivatives – Taylor's theorem – local mapping – the maximum principle.

**UNIT IV: THE GENERAL FORM OF CAUCHY'S THEOREM AND CALCULUS OF RESIDUES**

**15 hrs.**

Chains and cycles – simple connectivity – homology – general form of Cauchy's theorem (statement only) – harmonic functions – the mean value property – Poisson's formula – Schwarz's theorem.

**UNIT V: SERIES AND PRODUCT DEVELOPMENTS**

**15 hrs.**

Weierstrass's theorem – Taylor series – Laurent series – partial fractions – infinite products – canonical products – Gamma function – Stirling's formula

**TEXTBOOK(S):**

Lars V. Ahlfors, (2017). *Complex Analysis*, US: McGraw Hill Book Company, Print. Chapters 1,2,3(sections 2,3,4), 4,5(sections 1,2).

**REFERENCE BOOK(S):**

Conway, (1984). *Functions of one Complex Variable*, New York: Springer-Verlag. Print.

Deshphande J.V., (1986). *Complex Analysis*, New Delhi: TATA McGraw Hill Publishing Company Limited. Print.

Priestley H.A., (1990). *Introduction to Complex Analysis*, England: Oxford University Press. Print.

**ebook:**

Gogolin, AlexnaderO.,(2016). Lectures on Complex Integration. Retrieved from Springer

**WEBLINK(S):**

Nptelhrd. (2015, November 18). *Arzela-Ascoli Theorem*. [Video file]. Retrieved from <https://youtu.be/zqt7ubXble8>. CC BY license.

Khan Academy. (2016, August 6). *Laurent Series of Complex Functions*. [Video file]. Retrieved from <https://youtu.be/0ZOMkmy-aTo>. CC BY license.

**PGM3403CM GRAPH THEORY**

**(THEORY)**

**COURSE OUTCOMES:**

**5 hrs./ wk.**

On successful completion of the course, the student will be able to

**CO1:** define connectivity and traversability of a graph and prove the related theorems

**CO2:** analyse the types of digraphs and apply the same in proving the results on tournaments and decision making problems

**CO3:** find the matching, factorization and graceful labeling of graphs and prove results

**CO4:** define planarity and coloring of a graph and prove the results on the same

**CO5:** develop the bounds for the domination numbers of a graph

**COURSE CONTENT:**

**UNIT I: CONNECTIVITY AND TRAVERSABILITY**

**18 hrs.**

Cut vertices – blocks – connectivity – Menger's Theorem – Eulerian graphs – Hamiltonian graphs – Hamiltonian walks and numbers

**UNIT II: DIGRAPHS**

**15 hrs.**

Strong digraphs – tournaments – decision making

**UNIT III: MATCHINGS AND FACTORIZATION**

**15 hrs.**

Matchings – factorization – decompositions and graceful labelings – Petersen graph

**UNIT IV: PLANARITY AND COLORING**

**15 hrs.**

Planar graphs – embedding graphs on surfaces – graph minors – Four color problem – vertex coloring – edge coloring – Heawood map coloring theorem

**UNIT V: DOMINATION**

**12 hrs.**

The domination number of a graph

**TEXTBOOK(S):**

Gary Chartrand & Ping Zhang, (2006). *Introduction to Graph Theory*, New Delhi: Tata McGraw – Hill Publishing Company Ltd. Print. (Chapter 5(5.1-5.4),6(6.1-6.3),7(7.1-7.3),8 (8.1-8.3, 8.5), 9(9.1-9.3),10(10.1-10.4),13(13.1)

#### REFERENCE BOOK(S):

Kumaravelu S. & Susheela Kumaravelu, (1999). *Graph Theory*, Sivakasi: Janaki Calendar corporation. Print.

Harary, (2001). *Graph theory*, New Delhi: Narosa Publishing House Pvt Ltd. Print.

#### WEBLINK(S):

##### Video:

Bobby Lioyd. (2016, November 6). *Directed Graphs*. [Video file]. Retrieved from <https://youtu.be/by1zmpTxXlk>. CC BY license.

Center of Math. (2019, March 5). *Graph Theory: Tournaments*. [Video file]. Retrieved from <https://youtu.be/p5iKImnYbAo>. CC BY license

Graph theory for educators. (2016, February 16). *Menger's Theorem - 13*. [Video file]. Retrieved from <https://youtu.be/dUAeleBMRCQ>. CC BY license.

Itechnica. (2018, July 24). *Connectivity-Vertex & Edge Connectivity*. [Video file]. Retrieved from <https://youtu.be/R9R9hhue614>. CC BY license.

Itechnica. (2019, June 6). *Matching / Independent Edge Set*. [Video file]. Retrieved from <https://youtu.be/JXUnhNhNYc>. CC BY license.

Math at Andrews. (2020, March 22). *Graph Theory 4: Non-Planar Graphs & Kuratowski's Theorem*. [Video file]. Retrieved from - <https://youtu.be/3HyVikBzZ3g>. CC BY license.

Patrick JMT. (2010, November 17). *Euler Circuits and Euler Paths*. [Video file]. Retrieved from <https://youtu.be/REfC1-igKHQ>. CC BY license.

Udacity. (2016, June 6). *Maximal and maximum matching*. [Video file]. Retrieved from <https://youtu.be/bOJC93XxoFc>. CC BY license.

Video Empress. (2016, May 9). *Graceful labelling*. [Video file]. Retrieved from - <https://youtu.be/QNqdIRQuEH0>. CC BY license.

Sarada Herke. (2015, May 29). *Planar Graphs*. [Video file]. Retrieved from - <https://youtu.be/wnYtITkWAYA>. CC BY license.

Sarada Herke. (2015, August 1). *Colorability – vertex coloring*. [Video file]. Retrieved from - <https://youtu.be/4FE79y JkCE> CC BY license.

Sunilkumar Hosamani. (2020, April 23). *Examples for Domination number*. [Video file]. Retrieved from - <https://youtu.be/7NuM5unQYt4> CC BY license.

Up and Atom. (2018, August 20). *The Four Color Theorem | Coloring a Planar Graph* .[Video file].Retrieved from - <https://youtu.be/42-ws3bkrKM> CC BY license.

Wrath of Math. (2019, August 18). *What are Graph Decompositions? | Graph Decomposition, Graph Theory*. [Video file].Retrieved from [https://youtu.be/BiLjdZYj\\_RI](https://youtu.be/BiLjdZYj_RI). CC BY license.

## **PGM3404CM COMBINATORIAL THEORY**

### **(THEORY)**

#### **COURSE OUTCOMES:**

**5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** solve problems in permutations and combinations

**CO2:** construct generating functions and apply the same to solve problems

**CO3:** develop and solve recurrence relation for different problems

**CO4:** prove and apply principles of inclusion and exclusion

**CO5:** prove different results of counting and solve problems

#### **COURSE CONTENT:**

##### **UNIT I: PERMUTATIONS AND COMBINATIONS**

**15 hrs.**

Rules of Sum and product – permutations – combinations – distributions of distinct objects – distributions of nondistinct objects – Stirling's formula.

##### **UNIT II: GENERATING FUNCTIONS**

**15 hrs.**

Generating functions for combinations – enumerators for permutations – distributions of distinct objects into non distinct cells – partitions of integers – Ferrer's graph – elementary relations.

##### **UNIT III: RECURRENCE RELATIONS**

**15 hrs.**

Linear recurrence relations with constant coefficients – solution by the techniques of generating functions – a special class of nonlinear difference equations – recurrence relations with two indices.

##### **UNIT IV: PRINCIPLE OF INCLUSION AND EXCLUSION**

**15 hrs.**

Principle of inclusion and exclusion – the general formula – derangements – permutations with restrictions on relative positions – the rook polynomials – permutations with forbidden positions

##### **UNITV: POLYA'S THEORY OF COUNTING**

**15hrs.**

Equivalence classes under a permutation group – equivalence classes of functions – weights and inventories of functions – Polya's fundamental theorem – generalization of Polya's theorem.

#### **TEXTBOOK(S):**

Liu C.L., (1968). *An Introduction to Combinatorial Mathematics*, New York :McGraw - Hill Book Company, Print. Chapters 1,2,3,4,5 (except 5.2)

#### REFERENCE BOOK(S):

Alan Tucker, (2012). *Applied Combinatorics (6<sup>th</sup> ed.)*, New York :John Wiley & Sons, Inc.,.

John Riorden, (2002). *Introduction to Combinatorial Analysis*, New York :Dover Publications Inc., Print.

Krishnamurthy V., (2008). *Combinatorics -Theory and Applications*, New Delhi :Affiliated East-West Press Pvt. Ltd. Print.

#### WEBLINK(S):

Don't Memorise. (2015, July 22). *Permutations and Combinations - Circular Arrangement | Don't Memorise | GMAT/CAT/Bank PO/SSC CGL* [Video file] Retrieved from <https://youtu.be/0NAASclUm4k>. CC BY license.

Osman Nal (2016, January 20). *Burnside counting Lemma Part 1 of 3* [Video file] Retrieved from <https://youtu.be/VOrVMQjQpGg>. CC BY license.

Osman Nal (2016, January 20). *Burnside counting Lemma Part 2 of 3* [Video file] Retrieved from <https://youtu.be/QtZ9H5U0SwM>. CC BY license.

Osman Nal (2016, January 20). *Burnside counting Lemma Part 3 of 3* [Video file] Retrieved from <https://youtu.be/pheASxiQk2I>. CC BY license.

Osman Nal. (2020, April 22) *Polya Theorem Part I* [Video File]. Retrieved from <https://youtu.be/ehta4dsapeo>. CC BY license.

Trev Tutor, (2015, April 5). *Inclusion and Exclusion Principles -Discrete Mathematics* [Video file] Retrieved from <https://youtu.be/GS7dIWA6Hpo>. CC BY license.

## PGM3401MO FLUID DYNAMICS

### (THEORY)

#### COURSE OUTCOMES:

5 hrs./wk.

On successful completion of the course, the student will be able to

**CO1:** prove results on velocity and acceleration of a fluid at a point and solve related problems

**CO2:** develop Euler's equation and Bernoulli's equation and apply them in solving some problems of

practical importance

**CO3:** solve problems on sources, sinks and doublets, and prove results on stream function

**CO4:** prove results involving two-dimensional flow of inviscid incompressible fluids and solve related problems

**CO5:** make use of the stress components in a real fluid in solving problems in a viscous flow

## **COURSE CONTENT:**

### **UNIT I: KINEMATICS OF FLUIDS IN MOTION**

**15 hrs.**

Real fluids and ideal fluids – velocity of a fluid at a point – streamlines and path lines – steady and unsteady flows – velocity potential – vorticity vector – local and particle rates of change – equation of continuity – worked examples – acceleration of a fluid – conditions at a rigid boundary – general analysis of fluid motion

### **UNIT II: EQUATIONS OF MOTION OF A FLUID**

**15 hrs.**

Pressure at a point in a fluid at rest – pressure at a point in a moving fluid – conditions at a boundary of two inviscid immiscible fluids – Euler's equations of motion – Bernoulli's equation – worked examples – discussion of the case of steady motion under conservative body forces – some flows involving axial symmetry – some special two-dimensional flows – some further aspects of vortex motion

### **UNIT III: SOME THREE-DIMENSIONAL FLOWS**

**15 hrs.**

Introduction – sources – sinks and doublets – axis symmetric flows – Stoke's stream function – some special forms of the stream function for axis – symmetric irrotational motions

### **UNIT IV: SOME TWO-DIMENSIONAL FLOWS**

**15 hrs.**

Meaning of two-dimensional flow – use of cylindrical polar co-ordinates – stream function – complex potential for two-dimensional – irrotational – incompressible flow – complex velocity potential for standard two-dimensional flow: uniform stream – line sources and line sinks – line doublets – line vortices – some worked examples – Milne-Thomson circle theorem – some applications of the circle theorem – extension of the circle theorem – theorem of Blasius

### **UNIT V: VISCOUS FLOW**

**15 hrs.**

Stress components in a real fluid – relations between Cartesian components of stress – translational motion of fluid element – the rate of strain quadric and principal stress – some further properties of the rate of strain quadric – stress analysis in fluid motion – relations between stress and rate of strain – coefficient of viscosity and laminar flow – Navier-Stokes equations of motion of a viscous fluid – some solvable problems in viscous flow: steady motion between parallel planes – steady flow through tube of uniform circular cross section – steady flow between concentric rotating

cylinders – steady viscous flow in tubes of uniform cross section: a uniqueness theorem – tube having uniform elliptic cross-section – tube having equilateral triangular cross-section – diffusion of vorticity – energy dissipation due to viscosity

**TEXTBOOK(S):**

Chorlton F.,(2004). *Text book of Fluid Dynamics*, New Delhi: CBS Publishers and Distributors. Print. (Chapters 2, 3.1 to 3.7, 3.9, 3.10, 3.12, 4.1, 4.2, 4.5, 5.1 to 5.6, 5.8, 5.9, 8.1 to 8.11(8.11.1–8.11.3), 8.12, 8.13).

**REFERENCE BOOK(S):**

Bansal J.L., (1986). *Viscous Fluid Dynamics*, New Delhi:Oxford & IBH Publishers. Print.

Goyal & Gupta, (2016). *Fluid Dynamics*, Meerut: Pragati Prakashan Educational Publishers. Print.

Shanti Swarup, (1984). *Fluid Dynamics*, Agra: Krishna Prakash Mandhir Publishers. Print.

**WEBLINK(S):**

**Video**

MECH 241. (2017, May 3). *Fluid Mechanics I*[Video file]. Retrieved from <https://youtu.be/4qppw7dO7kM> . CC BY license.

Nptelhrd. (2015, March 24). *Fluid Kinematics* [Video file]. Retrieved from <https://youtu.be/whCu4Xl3m98> . CC BY license.

Nptelhrd. (2015, March 25). *Dynamics of Viscous Flows: Navier Stokes Equation*. [Video file]. Retrieved from <https://youtu.be/MSPTsseo-gs>. CC BY license.

## **PGM3402MO OPERATIONS RESEARCH**

### **(THEORY)**

**COURSE OUTCOMES:**

**5 hrs./wk.**

On successful completion of the course, the student will be able to

**CO1:** construct network models and solve problems using algorithms

**CO2:** solve linear programming problems using appropriate method

**CO3:** make use of deterministic dynamic programming to solve problems

**CO4:** decide on different alternatives on expected value criterion and make decision for relevant situations

**CO5:** apply simulation techniques in Queuing systems and Inventory problems

**COURSE CONTENT:**

**UNITI: NETWORK MODELS**

**15 hrs.**

Definition of network models – minimal spanning tree algorithm – maximal flow model: enumeration of cuts – maximal flow algorithm.

**UNIT II: REVISED SIMPLEX METHOD AND INTEGER LINEAR PROGRAMMING** **15 hrs.**

Standard forms for revised simplex method – computational procedure – comparison of simplex method and revised simplex method – branchandbound algorithm – cutting–plane algorithm.

**UNIT III: DETERMINISTIC DYNAMIC PROGRAMMING** **15 hrs.**

Recursive nature of computations in dynamic programming – forward and backward recursion – cargo loading model – work force size model.

**UNIT IV: DECISION ANALYSIS** **15hrs.**

Decision making under certainty – analytic hierarchy process – decision making under risk: decision tree based expected value criterion – variants of the expected value criterion – decision under uncertainty.

**UNIT V: SIMULATION** **15 hrs.**

Process of simulation – simulation models – event-type simulation – generation of random numbers – Monte–Carlo simulation – simulation of inventory problems – simulation of queuing system.

**TEXTBOOK(S):**

Hamdy A. Taha, (2014). *Operations Research: An Introduction*, (9<sup>th</sup> ed.), India: Pearson publication. Print. (Chapters 6 (Sections: 1,2,4(4.1,4.2)), 8 (Section: 2),11 (Sections:1,2,3(3.1,3.2)), 13 (Sections:1,2,3)).

Kanti Swarup P.K., Gupta and Man Mohan, (2015). *Operations Research*, New Delhi: Sultan Chand and Sons. Print. Chapter 22(22.1–22.9)

Sharma J.K., (2009). *Operations Research Theory and Applications*, (3<sup>rd</sup>ed.), Haryana: Macmillan India Ltd. Print. Chapter 26

**REFERENCE BOOK(S):**

Prem Kumar Gupta & Hira D.S., (2012). *Operations Research–An Introduction*, New Delhi: S. Chand and Co. Ltd. Print.

Rao S.S., (1984). *Optimization Theory and Applications*, New York: Halsted Press, Print.

**WEBLINK(S):**

**Videos:**

Arul Suju D. (2016, September 3). *Dynamic Programming: Solving Linear Programming Problem using Dynamic Programming Approach* [Video file]. Retrieved from [https://youtu.be/6v6\\_2Lo3\\_J4](https://youtu.be/6v6_2Lo3_J4). CC BY license.

Dbrownconsulting. (2018, May 20). *How to Incorporate the Monte Carlo Simulation on your financial models* [Video file]. Retrieved from <https://youtu.be/bR3Rdif5mhY>. CC BY license.

Mechpro classes. (2020, May 26). *Maximal flow problem* [Video file]. Retrieved from <https://youtu.be/lqjfsYifLtm>. CC BY license.

Mechpro classes. (2020, June 18). *Branch and Bound Technique for Integer Programming* [Video file]. Retrieved from [https://youtu.be/GNENEr\\_HclU](https://youtu.be/GNENEr_HclU). CC BY license.

WIT Solapur – Professional Learning Community. (2019, January 24). *Decision Making Under Certainty Solution by Assignment Method* [Video file]. Retrieved from <https://youtu.be/JufYC8AWf1Y>. CC BY license.

## **PGM3202EI FUZZY SETS AND ITS APPLICATIONS**

### **(THEORY)**

#### **COURSE OUTCOMES:**

**4 hrs./wk.**

On successful completion of the course, the student will be able to

CO1: compare fuzzy sets and crisp sets and define fuzzy logic

CO2: find union, intersection and complement of fuzzy sets and prove results on the same

CO3: discuss the properties of fuzzy relations and perform various compositions of fuzzy relations

CO4: construct fuzzy graphs and list the special fuzzy relations

CO5: apply fuzzy set theory in real life situations

#### **COURSE CONTENT:**

##### **UNIT I: FUZZY SETS**

**12 hrs.**

Crisp sets and fuzzy sets – basic concept of fuzzy set – fuzzy logic

##### **UNIT II: FUZZY OPERATION**

**12 hrs.**

Fuzzy complement – fuzzy union – fuzzy intersection – combinations of operations.

##### **UNIT III: FUZZY RELATION**

**12 hrs.**

Fuzzy relation on sets and fuzzy sets – composition of fuzzy relations – properties of the min-max composition.

##### **UNIT IV: FUZZY GRAPHS**

**12 hrs.**

Fuzzy graphs – special fuzzy relations.

##### **UNIT V: FUZZY APPLICATIONS**

**12 hrs.**

Fuzzy systems in medical field and genetic algorithm.

**TEXTBOOK(S):**

George J.Klir& Bo Yuan, (1995).*Fuzzy sets and Fuzzy Logic Theory and Applications*, New Delhi: Prentice Hall of India Pvt. Ltd. Print. (Chapter:17(17.2,17.4))

George J. Klir& Tina A.Folger, (2008). *Fuzzy sets, Uncertainty and Information*, New Delhi: Prentice Hall of India Pvt. Ltd.Print. (Chapter: 1(1.1-1.4,1.6),2(2.1 -2.5))

Zimmermann H.J., (2006). *Fuzzy set Theory and its Applications*, (4<sup>th</sup> ed.), New Delhi: Springer Publication. Print. (Chapter: 6 (6.1-6.3)).

**REFERENCE BOOK(S):**

Meenakshi A. R., (2008). *Fuzzy Matrix Theory and Applications*, Chennai: MJP Publishers. Print.

**WEBLINK(S):**

Atta KodallaVantillu. (2019, April 1).*FL – Classical Relations – Operations and Properties* [Video file]. Retrieved from <https://youtu.be/DzyCBHPTyIk>. CC BY license.

Mohamed Salih Mukthar. (2020, May 6). *Fuzzy Sets – Basic concepts* [Video file]. Retrieved from <https://youtu.be/RrseZK1obA> CC BY license.

Muhammad Adam Fahmil 'Ilmi. (2018, March 11).*Fuzzy Logic Application in Real Life – Robotics* [Video file]. Retrieved from <https://youtu.be/DW1eegaH6Ys> CC BY license.

Welcome Engineers. (2019, September 25).*Introduction to Graph in Tamil* [Video file]. Retrieved from <https://youtu.be/iH5PYVhX-Ks>CC BY license.

Zax Ong. (2016, March 5).*Fuzzy Logic in Real Life concepts* [Video file] Retrieved from [https://youtu.be/v\\_laulkyBCQ](https://youtu.be/v_laulkyBCQ) .CC BY license.

**PGM4601CM MODULE THEORY  
(THEORY)**

**LEARNING OUTCOMES:**

**6 hrs./wk.**

On successful completion of the course, the student will be able to

- understand the operations on ideals and their properties
- become familiar with the concepts of modules, Noetherian and Artinian rings
- develop abstract mathematical thinking

**COURSE CONTENT:**

**UNIT I: RINGS AND IDEALS**

**15 hrs.**

Rings and ring homomorphisms – ideals – quotient rings – zero-divisors – nilpotent elements – prime ideals and maximal ideals – nilradical and Jacobson radical – operations on ideals – extension and contraction.

**UNIT II: MODULES** **15 hrs.**

Modules and module homomorphisms – submodules and quotient modules – operations on submodules – direct sum and product – finitely generated modules – exact sequences.

**UNIT III: RINGS AND MODULES OF FRACTIONS** **15 hrs.**

Rings and modules of fractions – local properties – extended and contracted ideals in rings of fractions.

**UNIT IV: CHAIN CONDITIONS** **15 hrs.**

Noetherian A- modules – Artinian A- modules – Composition series.

**UNIT V: NOETHERIAN RINGS AND ARTIN RINGS.** **15 hrs.**

Hilbert Basis theorem – primary decomposition in Noetherian Rings – structure theorem.

**TEXTBOOK(S):**

Atiyah M.F. & MacDonald I.G., (1994). *Introduction to Commutative Algebra*, London: Addison-Wesley Publishing Company, Print. (Chapters 1, 2.1 to 2.9, 3(3.1-3.4, 3.8, 3.9, 3.11-3.16), 6, 7 (7.1- 7.6, 7.11 – 7-17) and 8.

**REFERENCE BOOK(S):**

Berrick A. J. & Keating M.E., (2000). *An introduction to rings and modules with K-theory in view*, New York: Cambridge University Press. Print.

Gopalakrishnan N.S., (1988). *Commutative Algebra*, New Delhi: Oxonian Press Pvt. Ltd, Print.

Musili C., (1999). *Introduction to Rings and Modules*, (2<sup>nd</sup> Revised Edition), New Delhi: Narosa Publishing House, Print.

## **PGM4602CM FUNCTIONAL ANALYSIS**

### **(THEORY)**

**LEARNING OUTCOMES:** **6 hrs./wk.**

On successful completion of the course the student will be able to

- discuss the role of completeness and its consequences for operators on Banach spaces
- analyse the properties of a Hilbert space.
- identify the role of linear operators on a Hilbert space

**COURSE CONTENT:**

**UNIT I: ALGEBRAIC SYSTEMS** **18 hrs.**

Linear spaces – dimension of a linear space – linear transformations – projections

**UNIT II: BANACH SPACES** **18 hrs.**

Definition and some examples – continuous linear transformations – Hahn Banach theorem

**UNIT III: BANACH SPACES (continued)** **18 hrs.**

Natural imbedding of  $N$  in  $N^{**}$  – open mapping theorem – closed graph theorem – conjugate of an operator.

**UNIT IV: HILBERT SPACES** **18 hrs.**

Definition and some simple properties – orthogonal complements – orthogonal sets – conjugate space  $H^*$ .

**UNIT V: FINITE DIMENSIONAL SPECTRAL THEORY** **18 hrs.**

Matrices – determinants and the spectrum of an operator – spectral theorem.

**TEXTBOOK(S):**

Simmons G.F., (2010). *Introduction to Topology and Modern analysis*, Tokyo: McGraw Hill Kogakusha Ltd. Print. (Chapters 8:42-44, 9: 46-51, 10: 52-55, 11: 60-62)

**REFERENCE BOOKS:**

Chandrasekhara Rao K., (2002). *Functional Analysis*, New Delhi: Narosa Publishing House, Print.

Saran N., Shukla S.L., (2001). *Functional Analysis*, Meerut: Pragati Prakashan, Print.

Sharma J.N., Vasishtha A.R., (2014). *Functional Analysis*, (35<sup>th</sup> ed.), KRISHNA Prakashan Media (P) Ltd., Print.

**PGM4501CM STOCHASTIC PROCESSES**  
**(THEORY)**

**LEARNING OUTCOMES:**

**6 hrs./wk.**

On successful completion of the course, the student will be able to

- interpret the concept of Stochastic and Markov Processes
- construct digraphs and form transition probability matrices
- apply Stochastic process in queuing theory

**COURSE CONTENT:**

**UNIT I: INTRODUCTION, MARKOV CHAINS** **15 hrs.**

Definition – examples and classification of stochastic processes – definition and examples of Markov Chains – transition matrix – Markov chain as graphs – classification of states and chains.

**UNIT II: HIGHER TRANSITION PROBABILITIES** **20 hrs.**

Theorems of Markov chains – determination of higher transition probabilities – stability of a Markov system – limiting behaviour – finite irreducible chains.

**UNIT III: POISSON PROCESS AND ITS EXTENSIONS** **20 hrs.**

Poisson process – postulates for Poisson process – derivation and properties of Poisson process – pure birth process: Yule-Furry process – birth immigration process – birth and death process.

**UNIT IV: RENEWAL PROCESSES** **15 hrs.**

Renewal interval – renewal function and renewal density – renewal equation – renewal theorems – branching process – properties of generating functions – examples.

**UNIT V: QUEUEING SYSTEMS AND MODELS** **20 hrs.**

Queueing processes – steady state distribution – little 's birth and death processes in queueing theory – the model M/M/S – Erlang loss model – Non-Markovian queueing models – queues with Poisson Input – model M/G/1.

**TEXTBOOK(S):**

Medhi, J., (2013). *Stochastic Processes*, (3<sup>rd</sup> ed.), New Delhi: New Age international publishers, Print. (Sections 1.5, 2.1 – 2.6, 3.1 – 3.2.1, 3.3.3 – 3.4.1, 6.1.1 – 6.5.1, 9.1 – 9.3.1, 10.1 – 10.3.1),

**REFERENCE BOOK(S):**

Karlin, S., & Taylor, H.W., (2012). *A First Course in Stochastic Processes*, (2<sup>nd</sup> ed.), United Kingdom: Academic Press, Gulf Professional Publishing, Print.

Karlin, S., & Taylor, H.W., (2012). *A Second Course in Stochastic Processes*, (2<sup>nd</sup> ed.) United Kingdom: Academic Press, Gulf Professional Publishing, Print.

Basu, A.K., (2007). *Introduction to Stochastic Processes*, New Delhi: Narosa Publishing House, Print.

**PGM4401CM NUMBER THEORY**

**(THEORY)**

**4 hrs. / wk.**

**LEARNING OUTCOMES:**

On successful completion of the course, the student will be able to

- find the greatest common divisor of two numbers using Euclidean algorithm and relate the concepts of divisibility and congruences
- discuss the properties of different arithmetical functions
- explain simple cryptosystems and solve enciphering matrices
- solve problems using public key Cryptography

**COURSE CONTENT:**

**UNIT I: DIVISIBILITY**

**15 hrs.**

Divisibility – greatest common divisor – Fundamental Theorem of Arithmetic – Euclidean Algorithm – basic properties of congruences – residue classes and complete residue systems – linear congruences – Polynomial congruences modulo  $p$  – Lagrange’s theorem and its applications – Chinese Remainder Theorem.

**UNIT II: ARITHMETICAL FUNCTIONS**

**15 hrs.**

Mobius function – Euler’s Tau function – Dirichlet product of Arithmetical functions – Mangoldt functions – multiplicative functions – Liouville’s function – Bell series of an Arithmetical function – Derivatives of Arithmetical functions.

**UNIT III: AVERAGE ORDER OF ARITHMETICAL FUNCTIONS**

**10 hrs.**

Euler’s summation formula – Average order of  $d(n)$ ,  $\Lambda(n)$ ,  $\sigma_\alpha(n)$ ,  $\mu(n)$ ,  $\phi(n)$  – partial sums of a Dirichlet product.

**UNIT IV: CRYPTOGRAPHY**

**10 hrs.**

Cryptography – some simple cryptosystems – enciphering matrices.

**UNIT V: PUBLIC KEY CRYPTOGRAPHY**

**10 hrs.**

Public key cryptography – the idea of public key cryptography – RSA – Discrete log – Knapsack cryptosystems.

**TEXTBOOK(S):**

Neal Koblitz., (1987). *Graduate Text in Mathematics A course in Number Theory and Cryptography*, New York: Springer – Verlag, Print. (Chapter 3, 4: 4.1 - 4.4).

Tom.M. Apostol., (1998). *Introduction to analytic Number theory*, New Delhi: Narosa Publishing house, Eighth reprint. - Print. (Chapters 1 to 3, 5: 5.1 - 5.7).

**REFERENCE BOOK(S):**

David.M. Burton., (2007). *Elementary Number Theory* 6<sup>th</sup> edition, New Delhi: Tata McGraw Hill Publishing House. Print.

Wade Trappe, Lawrence C Washington., (2007). *Introduction to Cryptography with coding theory* 2<sup>nd</sup> edition, New Delhi: Pearson Education. Print.

Hardy G.H & Wright E.M., (2003). *Theory of numbers*. USA: Oxford Science Publications. Print.

## **PGM4501MO COMBINATORIALTHEORY (THEORY)**

### **LEARNING OUTCOMES:**

**5hrs./wk.**

On successful completion of the course, the student will be able to

- distinguish between permutations and combinations in problem solving
- make use of generating functions and the principle of inclusion and exclusion to solve counting problems
- formulate and solve recurrence relations
- apply Polya's theory to count certain configurations in the combinatorial aspects

### **COURSE CONTENT:**

#### **UNIT I: PERMUTATIONS AND COMBINATIONS**

**15hrs.**

Rules of Sum and product –permutations –combinations –distributions of distinct objects – distributions of non-distinct objects –Stirling's formula.

#### **UNIT II: GENERATING FUNCTIONS**

**15hrs.**

Generating functions for combinations –enumerators for permutations –distributions of distinct objects into non distinct cells –partitions of integers –the Ferrer's graph –elementary relations.

#### **UNIT III: RECURRENCE RELATIONS**

**15hrs.**

Linear recurrence relations with constant coefficients –solution by the techniques of generating functions –a special class of nonlinear difference equations –recurrence relations with two indices.

#### **UNIT IV: PRINCIPLE OF INCLUSION AND EXCLUSION**

**15hrs.**

Principle of inclusion and exclusion –the general formula –derangements –permutations with restrictions on relative positions –the rook polynomials –permutations with forbidden positions

#### **UNIT V: POLYA'S THEORY OF COUNTING**

**15hrs.**

Equivalence classes under a permutation group –equivalence classes of functions –weights and inventories of functions –Polya's fundamental theorem –generalization of Polya's theorem.

### **TEXTBOOK(S):**

Liu.C.L., (1963). *An Introduction to Combinational Mathematics*, New Delhi: McGraw -Hill Book Company. Print.

Chapters 1,2,3,4,5 (except 5.2).

**REFERENCE BOOK(S):**

Daniel I.A. Cohn., *Basic Technique of combinational Theory*.USA:Cambridge University Press. Print.

John Riorden., *An introduction to combinational Analysis*, (Xerox material available in the department).Print.

Krishnamurthy. V., (1993). *Combinatorics theory and Applications*, New Delhi: Affiliated East-West Press Pvt. Ltd. Print.

Ryser.H.J., *Combinatorial Mathematics*, (Xerox material available in the department). Print

**PGM0202CD GRAPH THEORY AND ITS APPLICATIONS**

**(THEORY)**

**COURSE OUTCOMES:**

On successful completion of the course, the student will be able to

**CO1:** define different dominating sets and prove the related results

**CO2:** apply the algorithms to find the required results in graphs and digraphs

**CO3:** construct the flows in networks and prove theorems

**CO4:** determine edge connectivity and prove related results

**CO5:** apply the different concepts in digraphs, matchings, planarity, colorability and domination to solve problems

**COURSE CONTENT:**

**UNIT I: DOMINATION**

Domination sets – independent sets – irredundant sets – bounds – upper bounds – lower bounds – independent domination number – total domination number – connected domination number –global domination number.

**UNIT II: ALGORITHMS**

Tree Search Algorithms: tree search – breadth – first search and shortest paths – depth-first search finding the cut vertices and blocks of a graph – branching search – finding shortest paths in weighted digraphs – directed depth-first search – finding the strong components of a digraph

**UNIT III: FLOWS IN NETWORKS**

Transportation networks – max-flow min-cut theorem – four color theorem – Kempe chains –  
Kempe's erroneous proof – reducibility – unavoidability

#### **UNIT IV: GOMORY-HU TREES**

Determining edge connectivity – chordal graphs – clique cuts – simplicial vertices – tree  
representation

#### **UNIT V: APPLICATIONS**

Wine bottle problems – instant insanity – embedding graphs in Graphs – local coloring – lights  
out

#### **TEXTBOOK(S):**

Gary Chartrand & Ping Zhang, (2006). *Introduction to Graph Theory*, New Delhi:Tata McGraw  
– Hill Publishing Company Ltd. Print. (Chapter :7(7.4),8 (8.4), 9(9.4),10(10.5), 13(13.3).

Bondy & Murthy, (2008). *Graph Theory, USA*:Springer International Pvt  
Ltd.Print.(Chapter:6(6.1,6.3), Ch 7 (7.1,7.2), Ch9(9.6,9.7), Ch 15 (15.2).

Kulli V.R., (2010). *Theory of domination in graphs*, Mysore: Vishwa International Publications,  
Print. (Chapter: 2 (2.1 – 2.4), 3 (3.1 – 3.4, 3.9).

#### **REFERENCE BOOK(S):**

Teresa W. Haynes, Stephen Hedetniemi and Peter Slater, (1998). *Fundamentals of domination  
in graphs*, New York: Marcel Dekker, Inc., Print.

#### **WEBLINK(S):**

##### **Video**

Back to back SWE. (2019, October 27). *Network Flows: Max-Flow Min-Cut Theorem* (& Ford-  
Fulkerson

Algorithm) [Video file]. Retrieved from <https://youtu.be/oHy3ddI9X3o>. CC BY license.

Graph Theory for Educators (2016, April 17). *Intro Surfaces – 27* [Video file]. Retrieved from  
[https://youtu.be/2r\\_NTS8bHAW](https://youtu.be/2r_NTS8bHAW). CC BY license.

Go Gate IIT. (2013, February 17). *Depth First Search Algorithm* [Video file]. Retrieved from  
<https://youtu.be/iaBEKo5sM7w>. CC BY license.

Math at Andrews. (2020, April 2). *Graph Theory 8: Four Color Theorem* (Kempe's Proof), [Video  
file].

Retrieved from <https://youtu.be/adZZv4eEPs8>. CC BY License.

Michel Bierlaire. (2019, June 13). *Exact methods: Gomory cuts* [Video file]. Retrieved from  
<https://youtu.be/VdXHGNdnjjo>. CC BY license.

My code school. (2014, February 24). *Binary tree traversal - breadth-first and depth-first strategies*

[Video file]. Retrieved from <https://youtu.be/9RHO6jU--GU>. CC BY license.

PBS Infinite Serier (2018, April 26) *Instant Insanity Puzzle Infinite Series* [Video file]. Retrieved from

<https://youtu.be/Lw1pF47N-0Q>.CC BY license.

SunilkumarHosamani. (2020, April 23). *Examples for Domination number*[Video file]. Retrieved from

<https://youtu.be/7NuM5unQYt4>.CC BY license.

SunilkumarHosamani. (2020, May 4). *Bounds for Domination Number of a Graph*[Video file].

Retrieved from [https://youtu.be/R388D83JC\\_k](https://youtu.be/R388D83JC_k).CC BY license.

Scholartica Channel. (2015, September 4). *Connected Dominating Sets and its Applications: Part 1*[Video file].Retrieved from [https://youtu.be/HOgOQ9az\\_jo](https://youtu.be/HOgOQ9az_jo). CC BY license.

Turing Machines.(2019,Jun 22). *Depth First Search (DFS) on Directed graphs and Cyclic Graphs*[Video file]. Retrieved from <https://youtu.be/c7sUDqgrCaY>.CC BY license.

Wrath of Math. (2020, June 26). *Edge Cuts and Edge Connectivity | Graph Theory.* [Video file]

Retrieved from <https://youtu.be/grAiuM6tZuA>.CC BY license.