UNIVERSITY OF PUNE, PUNE
BOARD OF STUDIES IN MATHEMATICS
S. Y. B. A.(MATHEMATICS)
SYLLABUS

- **Structure of the course:**

MG-2	Discrete Mathematics + Linear Algebra
AMG-2	Multivariable Calculus I + Multivariable Calculus II
FMG-2	Operations Research + Optimization Techniques
MS -1	Problem Course based on MG-2 and AMG-2
MS-2	Number Theory +Computational Geometry

- **Equivalence of Previous syllabus along with new syllabus:**

New Course	**Old Course**
MG-2 Discrete Mathematics + Linear Algebra	MG-2: Differential Eqns. And Linear Algebra.
AMG-2 Multivariable Calculus I + Multivariable Calculus II	AMG-2: Calculus of Several Variables and Vector Calculus.
FMG-2 Operations Research + Optimization Techniques	FMG-2: Operations Research
MS -1 Problem Course based on MG-2 and AMG-2	MS-1: a) Number Theory and Complex Variables OR b) Prob. Course based on the Papers MG 2 and AMG 2(Same as Paper III of SYBSc Mathematics)
MS-2 Number Theory +Computational Geometry	MS-2: a) Combinatorics and Computational Geometry. OR b) Graphs and Lattices.

Details of Syllabus:

Paper MG-2 :- Discrete Mathematics + Linear Algebra

First term: Discrete Mathematics

1. **Logic and Proofs:** **[24]**
   - 1.1 Propositional logic.
   - 1.2 Propositional equivalences.
   - 1.3 Predicates and quantifiers.
   - 1.4 Nested quantifiers.
   - 1.5 Rules of inference.
   - 1.6 Introduction to proofs.
2. **Counting:** **[20]**
   - 2.1 The basics of counting.
   - 2.2 Permutation and combinations.
   - 2.3 Generalized permutation and combinations.
3. **Advanced Counting Technique:** **[04]**
   - 3.1 Inclusion-Exclusion (without proof).

Text Book:

1. Discrete Mathematics and Its Applications, Kenneth H Rosen, Seventh Edition, McGraw Hill.

Sections: 1.1 to 1.6, 5.1, 5.3, 5.5, 6.5

Reference Books:

1. Symbolic Logic, I.M. Copi, Fifth Edition, Prentice Hall of India, 1995.
2. Bernard Kolman, Robert C. Busby, Sharon Cutler Ross and Nadeem-ur-Rehman: Discrete Mathematical Structures, Fifth Edition, Pearson Education, Inc., 2004.
3. Applied Combinatorics, Fourth Edition, by Alan Tucker.

Second Term : Linear Algebra

1. **Vector Spaces** **[16]**
   Definition, examples, linear dependence, basis and dimension, vector subspace, Necessary and sufficient condition for subspace, vector space as a direct sum of subspaces

2. **Inner Product Spaces** **[16]**
   Inner product, norm as length of a vector, distance between two vectors, orthonormal basis, orthonormal projection,Gram Schmidt processs of ortogonalization, null space, range space, rank, nullity, Sylvester Inequality

3. **Linear Transformations** **[16]**

   Definition, examples, properties of linear transformations, equality of linear transformations, kernel and rank of linear transformations, composite transformations, Inverse of a linear transformation, Matrix of a linear transformation, change of basis, similar matrices

Textbook Book:

Matrix and Linear Algebra aided with MATLAB, Kanti Bhushan Datta, PHI learning Pvt.Ltd, New Delhi(2009**) (**Sections:5.1,5.2,5.3,5.4,5.5,5.7,6.1,6.2,6.3,6.4

Reference Books:

1. Howard Anton, Chris Rorres., Elementary Linear Algebra,John Wiley & Sons, Inc
2. K. Hoffmann and R. Kunze Linear Algebra, Second Ed. Prentice Hall of India , New Delhi, (1998).
3. S. Lang, Introduction to Linear Algebra, Second Ed. Springer-Verlag, New Yark.
4. A. Ramchandra Rao and P. Bhimasankaran, Linear Algebra, Tata McGraw Hill,New Delhi (1994).
5. G. Strang, Linear Algebra and its Applications. Third Ed. Harcourt Brace Jovanovich, Orlando, (1988).

Paper AMG-2: Multivariable Calculus I + Multivariable Calculus II

Term I: Multivariable Calculus I

1. **Limit and Continuity of Multivariable functions**: **[06]**
   1.1. Functions of several variables, graphs and level curves of function of two variables.
   1.2. Limit and Continuity in higher dimensions.
2. **Partial Derivatives:** **[04]**
   2.1. Definition and examples.
   2.2. Second order partial derivative, the mixed derivative theorem.
   2.3. Partial derivatives of higher order.
3. **Differentiability:** **[12]**
   3.1. Differentiability, the increment theorem for functions of two variables (without proof).
   3.2. Chain rules for composite function.
   3.3. Directional derivatives, gradient vectors.
   3.4. Tangent planes, normal lines and differentials.
4. **Extreme Values:** **[10]**
   4.1. Extreme values, First derivative test and Second derivative test for local extreme values.

4.2. Lagrange's multipliers method for finding extreme values of constraint function (One Constraint)

4.3. Taylors Formula for two variables.

5. Multiple Integrals: [16]

5.1. Double Integral over rectangles, Fubini's theorem for calculating double integrals (Without proof).

5.2. Double integrals in polar form.

5.3. Triple integrals in rectangular coordinates.

5.4. Triple integral in cylindrical and spherical coordinates.

5.5. Substitution in multiple integrals, Application to area and volumes.

Text Book: Thomas' Calculus, 11th Edition, G. B. Thomas.
Revised by Maurice D. Weir, Joel Hass and Frank R. Giordano.
Pearson Edition 2012.
Articles: 14.1 to 14.10, 15.1, 15.3, 15.4, 15.6, 15.7

Reference Books:

1. Basic Multivariable Calculus, J. E. Marsden, A. J. Tromba , A. Weinstein, Springer Verlag (Indian Edition).
2. Shanti Narayan, R.K. Mittal, A Text-book of Vector Calculus, S.Chand and Company.
3. D.V. Widder, Advanced Calculus (2nd Edition), Prentice Hall of India ,NewDelhi,(1944).
4. T.M. Apostol , Calculus Vol. II (2nd Edition), John Wiley, New York, (1967).

Term II:Multivariable Calculus II

1. Vector valued function: [14]

1.1 Vector valued function.

1.2 Limit and Continuity of vector function.

1.3 Derivative of vector function and motion.

1.4 Differentiations rules.

1.5 Constant vector function and its necessary and sufficient condition.

1.6 Integration of vector function of one scalar variable.

1.7 Arc length and unit tangent vector T. Curvature and the unit normal vector N.

2. Line Integrals: [16]

2.1 Definition and evaluation of line integral.

2.2 Properties of line integrals.

2.3 Vector fields, work, circulation and flux across smooth curves.

2.4 Path independence, Potential functions, Conservative fields.

2.5 Green's theorem in plane, evaluating integrals using Green's theorem.

3. **Surface and volume integrals:** **[18]**
   - **3.1** Surface area and surface integrals.
   - **3.2** Surface integral for parameterized surfaces.
   - **3.3** Stokes theorem (without proof).
   - **3.4** The Gauss divergence theorem (proof for special regions).

Textbook Book:

Thomas' Calculus, 11th Edition, G. B. Thomas.Revised by Maurice D. Weir, Joel Hass and Frank R. Giordano. Pearson Edition 2012.Articles: 13.1, 13.3, 13.4, 16.1 to 16.8.

Reference Books:

1. Basic Multivariable Calculus, J. E. Marsden, A. J. Tromba , A. Weinstein, Springer Verlag (Indian Edition).
2. Shanti Narayan, R.K. Mittal, A Text-book of Vector Calculus, S.Chand and Company.
3. John M. H. Olmsted, Advanced Calculus, Eurasia Publishing House, NewDelhi(1970).
4. T.M. Apostol , Calculus Vol. II (2nd Edition), John Wiley, New York, (1967).

Paper FMG-2:- Operations Research + Optimization Techniques

Term I :Operations Research

1. Modeling with Linear Programming **[8]**

Two variable LP Model, Graphical LP solution, Selected LP Applications

2. The Simplex Method **[16]**

LP Model in equation form, Transition from graphical to algebraic solutions, The simplex method, Artfiicial starting solutions,Sensitivity analysis.

3. Duality **[6]**

Definition of the dual problem, Primal dual relationship

4. Transportation Model **[12]**

Definition of the Transportation model, The Transportation algorithm.

5. The Assignment Model **[6]**

The Hungarian method, Simplex explanation of the Hungarian method.

Text Book: Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice

Hall of India Pvt. Ltd, New Delhi.

Ch.2: 2.1,2.2,2.3(2.3.4, 2.3.5, 2.3.6).

Ch.3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (3.6.1).

Ch.4: 4.1, 4.2.

Ch.5: 5.1,5.3 (5.3.1, 5.3.2, 5.3.3), 5.4(5.4.1, 5.4.2).

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operation Research

(Eighth Edition) Tata McGraw Hill.

2. J K Sharma, Operations Research (Theory and Applications, second edition,

2006), Macmilan India Ltd.

3. Hira and Gupta, Operation Research.

Term II: Optimization Techniques

1. Network Models **[12]**

CPM and PERT, Network representation, Critical Path Computations, Construction of the time schedule, Linear programming formulation of CPM, PERT calculations

2. Decision Analysis and Games **[12]**

Decision under uncertainty, Game theory, Some basic terminologies, Optimal solution of two person zero sum game, Solution of mixed strategy games, graphical solution of games, linear programming solution of games.

3. Replacement and Maintenance Models **[6]**

Introduction, Types of failure, Replacement of items whose efficiency deteriorates with time.

4. Sequencing Problems **[6]**

Introduction, Notation, terminology and assumptions, Processing n jobsthrough two machines, Processing n jobs through three machines.

5. Classical Optimization Theory **[12]**

Unconstrained problems, Necessary and sucient conditions, Newton Raphson method, Constrained problems, Equality constraints.

Text Book:

1. Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.

Ch.6: 6.5 (6.5.1,6.5.2,6.5.3,6.5.4,6.5.5).

Ch.13: 13.3, 13.4(13.4.1,13.4.2,13.4.3).

Ch.18: 18.1(18.1.1, 18.1.2), 18.2 (18.2.1).

2. J K Sharma, Operations Research (Theory and Applications, second edition,2006), Macmilan India Ltd.

Ch.17: 17.1,17.2, 17.3.

Ch.20: 20.1, 20.2, 20.3, 20.4.

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operation Research

(Eighth Edition) Tata McGraw Hill.

2. Hira and Gupta, Operation Research.

Paper MS-2:- Number Theory +Computational Geometry

Term I: Number Theory

1.Divisibility **[8]**

Divisibility in integers, Division Algorithm, GCD, LCM, Fundamental theorem of

Arithmetic, Infinitude of primes, Mersene Numbers and Fermat Numbers.

2.Congruences **[12]**

Properties of congruences, Residue classes, complete and reduced residue system,

their properties, Fermat's theorem. Euler's theorem, Wilson's theorem, $x^2 \equiv -1(mod\ p)$ has a solution if and only if p = 2 or $p \equiv 1\ (mod\ 4)$; where p is a prime.Linear congruences of degree 1, Chinese remainder theorem.

3.Greatest integer function, Arithmetic functions [10]

Euler's ϕ function, the number of divisors $d(n)$,sum of divisors $\sigma(n)$; $\sigma_k(n)$; $\omega(n)$; and

$\Omega(n)$: Multiplicative functions, Totally Multiplicative Functions, Mobius function,

Mobius inversion formula.

4.Quadratic Reciprocity [10]

Quadratic residues, Legendre's symbol. Its properties, Law of quadratic reciprocity**.**

5.Diophantine Equations [8]

ax + by = c and Pythagorean triplets**.**

Text Book:

I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers,

5th Edition, John Wiley and Sons.

1.1; 1.2; 1.3; 2.1; 2.2; 2.3; 3.1; 3.2; 3.3; 4.1; 4.2; 4.3; 5.1; and 5.3

Reference Book:

David M. Burton, Elementary Number Theory (Second Ed.), Universal Book

Stall, New Delhi, 1991.

Term II: Computational Geometry

1. **Two dimensional Transformations [12]**

Representation of Points, Transformations and Matrices, Transformation of Points,

Transformation of Straight Lines, Midpoint Transformation, Transformation of Parallel Lines, Transformation of Intersecting Lines, Rotation, Reflection, Scaling, Combined Transformations, Transformation of the Unit Square, Solid Body Transformation, Translations and Homogeneous Coordinates, Rotation About an Arbitrary Point, Reflection Through an Arbitrary Line, Projection - A Geometric Interpretation of Homogeneous Coordinates, Overall Scaling, Points at Infinity, TransformationConventions.

2.Three Dimensional Transformations [12]

Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation. Three-Dimensional Reflection. Three-Dimensional Translation. Multiple Transformations, Rotations about an Axis Parallel to a coordinate axis, Rotation about an Arbitrary Axis in Space, Reflection Through an Arbitrary Plane. Affine and Perspective Geometry, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformations. Techniques for generating perspective views, Vanishing points, photography and the perspective transformation, stereographic projection, comparison of object fixed and center of projection , Fixed projections, reconstruction of three-dimensional images.

3.Plane Curves [12]

Curve representation, non-parametric curves, parametric curves, parametric representation of a circle, parametric representation of an Ellipse, parametric representation of a parabola, Parametric representation of a Hyperbola. A procedure for using conic sections. The general conic equations.

4.Space Curves [12]

Bezier curves introduction, definition, properties (without proofs), curve fitting (up to n = 3), equation of the curve in matrix form (up to n = 3).B-spline curves introduction, definition, properties(without proof).

Text-Book:

D.F. Rogers, J. Alan Adams, Mathematical Elements of Computer Graphics, Second

Edition, McGraw-Hill Publishing Company.
