University of Kerala

Complementary Course in Mathematics for First Degree Programme in Chemistry

Semester I

Mathematics – I

Code: MM 1131.2(Calculus with applications in Chemistry – I)

Instructional hours per week: 4 No. of Credits:3

Module 1: Differentiation with applications to Chemistry (18 Hours) (*The following topics should be quickly reviewed before going to advanced topics; students should be asked to do more problems from exercises, and these problems should be included in assignments:*) Differentiation of products of functions; the chain rule; quotients; im- plicit differentiation; logarithmic differentiation; Leibnitz theorem

The following topics in this module should be devoted more attention and time.

Special points of a function (especially, stationary points); curvature; theorems of differ- entiation – Rolles', Mean Value Theorems

The topics in this module can be found in chapter 2, sections 2.1.2, to 2.1.7, text [1] *(Re- view of ideas through problems), chapter 2, sections 2.1.8, 2.1.9, 2.1.10,* text [1]

More exercises related to the topics in this module can be found in chapter 2 and chapter 3 of reference [1].

Module 2 : Complex numbers and hyperbolic functions (18 hours) Basic operations (Addition and subtraction; modulus and argument; multiplication; com- plex conjugate; division), Polar representation of complex numbers (Multiplication and division in polar form), de Moivers theorem (trigonometric identities; finding the nth roots of unity; solving polynomial equations), Complex logarithms and complex powers, Applications to differentiation and integration, Hyperbolic functions (Definitions; hyper- bolictrigonometric analogies; identities of hyperbolic functions; solving hyperbolic equa- tions; inverses of hyperbolic functions;calculus of hyperbolic functions)

The topics in this module can be found in chapter 3, sections 3.1 to 3.7 of text [1]

More exercises related to the topics in this module can be found in chapter 6 of reference [1] and chapter 13 of reference [4].

Module 3: Basic vector algebra (18 Hours) Scalars and vectors, Addition and subtraction of vectors, Multiplication by a scalar, Basis vectors and components, Magnitude of a vector, Multiplication of vectors (Scalar product; vector product; scalar triple product; vector triple product), Equations of lines, planes and spheres, using vectors to find distances (Point to line; point to plane; line to line; line to plane)

The topics in this module can be found in chapter 7, sections 7.1 to 7.8, text [1]

More exercises related to the topics in this module can be found in chapter 11 of reference [1] and chapter 6 of reference [2].

Module 4: Basic integration with applications to Chemistry (18 Hours) Integration by parts; reduction formulae; infinite and improper integrals; plane polar coordinates; integral inequalities; applications of integration (finding area, volume etc) *The topics in this module can be found in chapter 2, sections 2.2.8 to 2.2.13,* text [1]

More exercises related to the topics in this module can be found in chapter 4, 5 and 7 of reference [1].

Texts

Text 1 – K F Riley, M P Hobson, S J Bence. *Mathematical Methods for Physics and Engineering*, 3rd Edition, Cambridge University Press

References

Ref. 1 – H Anton, I Bivens, S Davis. *Calculus*, 10th Edition, John Wiley & Sons

Ref. 2 – Mary L Boas. *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley

Ref. 3 – George B Arfken, Hans J Weber, Frank E Harris. *Mathematical Methods for Physicists*, 7th Edition, Academic Press

Ref. 4 – Erwin Kreyszig. *Advanced Engineering Mathematics*, 10th Edition, Wiley-India

Semester II

Mathematics – II

Code: MM 1231.2**(Calculus with applications in Chemistry – II)**

Instructional hours per week: 4 No. of Credits: 3

Module 1 : Partial differentiation (18 Hours)

Basics, The total differential and total derivative, Exact and inexact differentials, theo- rems of partial differentiation, The chain rule, Change of variables, Taylors theorem for many-variable functions, Stationary values of many-variable functions, Stationary values under constraints

The topics in this module can be found in chapter 5, sections 5.1 to 5.9 of text [1]

More exercises related to the topics in this module can be found in chapter 13 of reference [1].

Module 2: Infinite series and limits(18 Hours)

Definition, Summation of series of various types (Arithmetic series; geometric series; arithmetico-geometric series; the difference method; series involving natural numbers; transformation of series) Convergence of infinite series (Absolute and conditional con- vergence; series containing only real positive terms; alternating series test)

Operations with series (Sum and product)

Power series (Convergence of power series; operations with power series)

Taylor series (Taylors theorem need not be proved, but the statement should be explained through problems); approximation errors; standard Maclaurin series

The topics in this module can be found in chapter 4, sections 4.1 to 4.6, text [1]

More exercises related to the topics in this module can be found in chapter 9 of reference [1] and chapter 1 of reference [2].

Module 3 : Vector differentiation (18 Hours)

Differentiation of vectors , Composite vector expressions; differential of a vector, Integra- tion of vectors, Space curves, Vector functions of several arguments, Surfaces, Scalar and vector fields

Vector operators, Gradient of a scalar field; divergence of a vector field; curl of a vector field Vector operator formulae, Vector operators acting on sums and products; combina- tions of grad, div and curl, Cylindrical and spherical polar coordinates

The topics in this module can be found in chapter 10, sections 10.1 to 10.9 of text [1]. *More exercises related to the topics in this module can be found in chapter 3 of reference [3].*

Module 4 : Multiple integrals (18 Hours)

Double integrals, Triple integrals, Applications of multiple integrals (Areas and volumes), Change of variables in multiple integrals – Change of variables in double integrals; evalua- tion some special infinite integrals, change of variables in triple integrals; general properties of Jacobians

The topics in this module can be found in chapter 6, sections 6.1 to 6.4 of text [1]

More exercises related to the topics in this module can be found in chapter 14 of reference [1].

Texts

Text 1 – K F Riley, M P Hobson, S J Bence. *Mathematical Methods for Physics and Engineering*, 3rd Edition, Cambridge University Press

References

Ref. 1 – H Anton, I Bivens, S Davis. *Calculus*, 10th Edition, John Wiley & Sons

Ref. 2 – Mary L Boas. *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley

Ref. 3 – George B Arfken, Hans J Weber, Frank E Harris. *Mathematical Methods for Physicists*, 7th Edition, Academic Press

Ref. 4 – Erwin Kreyszig. *Advanced Engineering Mathematics*, 10th Edition, Wiley-India

Semester III

Mathematics – III

Code: MM 1331.2**(Linear Algebra, Probablity Theory & Numerical Methods)**
Instructional hours per week:5 No. of Credits: 4

Module 1 : Basic Linear Algebra (24 Hours)

Matrices and row reduction, Determinants, Cramer's rule for solving system of equations, vectors, lines and planes, linear combinations, linear functions, linear operators, linear dependence and independence, special matrices like Hermitian matrices and formulas, linear vector spaces, eigen values and eigen vectors, diagonalizing matrices, applications of diagonalization

The topics in this module can be found in chapter 3 of text [2]

More exercises related to the topics in this module can be found in chapter 7 and 8 of reference [3].

Module 2 : Probability and Statistics (36 Hours)

Basics, Sample Space, Probability Theorems, Methods of Counting Random Variables, Continuous Distributions, Binomial Distribution, The Normal or Gaussian Distribution, The Poisson Distribution

The topics in this module can be found in chapter 15, sections 15.1 to 15.9 of text [2]

More exercises related to the topics in this module can be found in chapter 23 of reference [2].

Module 3 : Numerical Methods (30 Hours)

Algebraic and transcendental equations (Rearrangement of the equation; linear interpola- tion; binary chopping; Newton-Raphson method)
Convergence of iteration schemes, Simultaneous linear equations (Gaussian elimination; Gauss-Seidel iteration; tridiagonal matrices) Numerical integration (Trapezium rule; Simp- sons rule; Gaussian integration; Monte Carlo methods), Finite differences, Differential equations (Difference equations; Taylor series solutions; prediction and correction;Runge-Kutta methods; isoclines)

The topics in this module can be found in chapter 27, sections 27.1 to 27.6 of text [1]

More exercises related to the topics in this module can be found in reference [4].

Texts

Text 1 – K F Riley, M P Hobson, S J Bence. *Mathematical Methods for Physics and Engineering*, 3rd Edition, Cambridge University Press

Text 2 – Mary L Boas. *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley

References

Ref. 1 – H Anton, I Bivens, S Davis. *Calculus*, 10th Edition, John Wiley & Sons

Ref. 2 – George B Arfken, Hans J Weber, Frank E Harris. *Mathematical Methods for Physicists*, 7th Edition, Academic Press

Ref. 3 – Erwin Kreyszig. *Advanced Engineering Mathematics*, 10th Edition, Wiley-India

Ref. 4 – Richard L Burden, J Douglas Faires. *Numerical Analysis*, 9th Edition, Cengate Learning

Semester IV

Mathematics-IV

Code: MM 1431.2**(Differential Equations, Vector Calculus, and Abstsract Algebra)**

Module 1 : Ordinary Differential Equations(30 Hours)

First-order ordinary differential equations : General form of solution, First-degree first- order equations (Separable-variable equations; exact equations; inexact equations, inte- grating factors; linear equations; homogeneous equations; isobaric equations; Bernoullis equation; miscellaneous equations) Higher-degree first-order equations (Equations soluble for p; for x; for y; Clairaut's equation)

Higher-order ordinary differential equations : Linear equations with constant coeffi- cients, (Finding the complementary function $y_c(x)$; finding the particular integral $y_p(x)$; constructing the general solution $y_c(x) + y_p(x)$; linear recurrence relations; Laplace trans- form method) Linear equations with variable coefficients (The Legendre and Euler linear equations; exact equations; partially known complementary function; variation of param- eters; Green's functions; canonical form for second-order equations)

General ordinary differential equations – Dependent variable absent; independent vari- able absent; non-linear exact equations; isobaric or homogeneous equations; equations ho- mogeneous in x or y alone; equations having $y = Ae^x$ as a solution

The topics in this module can be found in chapter 14 and chapter 15 of text [1]

More exercises related to the topics in this module can be found in chapter 1, 2 and 3 of reference [3].

Module 2 : Vector Integration – Line, surface and volume integrals (18 hours)

Evaluating line integrals; physical examples; line integrals with respect to a scalar Connec- tivity of regions, Greens theorem in a plane, Conservative fields and potentials, Surface integrals, Evaluating surface integrals; vector areas of surfaces; physical examples, Vol- ume integrals, Volumes of three-dimensional regions, Integral forms for grad, div and curl, Green's theorems (without proof); other related integral theorems; physical applications, Stokes theorem and related theorems (without proof), Related integral theorems; physical applications

The topics in this module can be found in chapter 11 of text [1]

More exercises related to the topics in this module can be found in chapter 3 of reference [2].

Module 3: Abstract Algebra (42 Hours)

Definition of a group; examples of groups, Finite groups, Non-Abelian groups, Permutation groups, Mappings between groups, Subgroups Subdividing a group (Equivalence relations and classes; congruence and cosets; conjugates and classes)

Representation theory, Equivalent representations, Reducibility of a representation, The orthogonality theorem for irreducible representations Characters (Orthogonality prop- erty of characters), Counting irreps using characters (Summation rules for irreps), Construction of a character table

The topics in this module can be found in chapter 28 and chapter 29, sections 29.3, 29.4, 29.5, 29.6, 29.7, 29.8 of text [1]

More exercises related to the topics in this module can be found in reference [5].

Texts

Text 1 – K F Riley, M P Hobson, S J Bence. *Mathematical Methods for Physics and Engineering*, 3rd Edition, Cambridge University Press

References

Ref. 1 – H Anton, I Bivens, S Davis. *Calculus*, 10th Edition, John Wiley & Sons

Ref. 2 – Mary L Boas. *Mathematics Methods in the Physical Sciences*, 3rd Edition, Wiley

Ref. 3 – George B Arfken, Hans J Weber, Frank E Harris. *Mathematical Methods for Physicists*, 7th Edition, Academic Press

Ref. 4 – Erwin Kreyszig. *Advanced Engineering Mathematics*, 10th Edition, Wiley-India

Ref. 5 – David M Bishop. *Group theory and Chemistry*, Dover Publications