Physical Science Level I and Level II

Level	Semester	Prerequisites	Course Unit	Title	Credit Value	Hours	P1	P2	P3	P4	P5	P6	
I	S1		AM 1011	Fundamental Applied Mathematics	2	30 L	X	X	X	X	X	X	*
			AM 1012	Vector Calculus	2	30 L	O	O	O	O	O	O	
	S2	AM 1011	AM 1013	Differential Equations I	2	30 L	X	X	X	X	X	X	*
		AM 1011	AM 1014	Applied Linear Algebra	2	30 L	X	X	X	X	X	X	*
			AM 1015	Computational Mathematics I	2	60 P	O	O	O	O	O	O	
	S1		PM 1011	Foundations of Mathematics	2	30 L	O	O	X	O	X	X	
			PM 1012	Introduction to Number Theory	2	30 L			X		X	X	
	S2	PM 1011	PM 1013	Basic Analysis I	2	30 L			X		X	X	
			PM 1014	History as Motivation for Mathematics	2	30 L	O	O	O	O	O	O	
II	S1	AM 1013	AM 2011	Differential Equations II	2	30 L	X	X	X	X	X	X	*
		AM 1014	AM 2012	Linear Programming	2	30 L	X	X	X	X	X	X	*
	S2	AM 2011	AM 2013	Numerical Analysis	2	30 L	X	X	X	X	X	X	*
		AM 2012	AM 2014	Optimization	2	30 L	O	O	O	O	O	O	
		AM 1015	AM 2015	Computational Mathematics II	2	60 P	O	O	O	O	O	O	
	S1	PM 1013	PM 2011	Basic Analysis II	2	30 L			X		X	X	
		PM 1012	PM 2013	Introduction to Abstract Algebra	2	30 L			X		X	X	
	S2	PM 2011	PM 2012	Basic Analysis III	2	30 L			X		X	X	

Industrial Statistics & Mathematical Finance Level I & II

Level	Semester	Prerequisites	Course Unit	Title	Credit Value	Hours	Core or Elective
I	S1		FM 1011	Financial Mathematics I	2	30 L	X
			FM 1013	Linear Programming	2	30 L	O
			MS 1011	Computing for Finance	1	30 P	X
			PM 1011	Foundations of Mathematics	2	30 L	X
	S2		FM 1012	Mathematical Methods for Finance I	2	30 L	O
			FM 1014	Computational Financial Mathematics I	2	60 P	O
			MS 1012	Mathematical Economics	2	30 L	X
		PM 1011	PM 1013	Basic Analysis I	2	30 L	X
II	S1	FM 1011	FM 2011	Financial Mathematics II	2	30 L	O
			FM 2012	Linear Algebra	2	30 L	O
			MS 2011	Numerical Methods for Finance	2	20 L 20 P	X
		PM 1013	PM 2011	Basic Analysis II	2	30 L	X
	S2	FM 1101	FM 2013	Actuarial Mathematics I	2	30 L	X
		FM 1014	FM 2014	Computational Financial Mathematics II	2	60 P	O
			MS 2012	Introduction to Insurance	1	15 L	X
		PM 2011	PM 2012	Basic Analysis III	2	30 L	X

X : Core Courses O: Elective Courses *: Compulsory Courses

L: Lectures P: Practical/Labs

Physical Science Level III

Semester	Prerequisites	Course Unit	Title	Credit Value	Hours	Core or Elective
S1		AM 3031	Mathematical Methods I	3	45 L	X
	AM 2015	AM 3035	Discrete Applied Mathematics	3	30 L 30 P	X
		PM 3011	Real Analysis	3	45 L	X
S2		AM 3011	Mathematical Modeling	3	30 L 30 P	O
		PM 3012	Abstract Algebra	3	45 L	X

Industrial Statistics & Mathematical Finance Level III

Semester	Prerequisites	Course Unit	Title	Credit Value	Hours	Core or Elective
S1	FM 1012	FM 3031	Mathematical Methods for Finance II	3	30 L 30 P	X
	FM 2011	FM 3034	Financial Mathematics III	2	20L 20P	X
		MS 3108	Accounting for Finance	3	45 L	X
S2	FM 3034	FM 3011	Financial Mathematics Seminar	1	30 P	O
		AM 3011	Mathematical Modeling	3	30 L 30 P	O
	FM 2013	FM 3033	Actuarial Mathematics II	3	45 L	X

X : Core Courses   O: Elective Courses   *: Compulsory Courses

L: Lectures   P: Practical/Labs

B.Sc. Honours Research Oriented Level III

Level & Semester	Prerequisites	Course Unit	Title	Credit Value	Hours	BSc Honors Degree in			
						Mathematics	Applied Mathematics	Computational Mathematics	Mathematical Finance
Level III S1		AM3031	Mathematical Methods I	3	45 L	O	X	X	
		AM3032	Numerical Methods and Scientific Computing I	2	60 P		X		
		AM3033	Applied Dynamical Systems	3	30 L 30 P	O	X		
	AM2015	AM3035	Discrete Applied Mathematics	3	30 L 30 P	O	X	X	O
		PM3031	Linear Algebra	3	45 L	X			
		PM3033	Real Analysis I	3	45 L	X	X		X
		PM3036	Topology I	3	45 L	X	O		
		AM3081	Applied Analysis	3	45 L			X	
		AM3082	Theory of Computation	3	45 L			X	
		AM3083	Computational Methods and Scientific Computing I	2	60 P			X	
	FM 1012	FM3031	Mathematical Methods for Finance II	3	30 L 30 P				X
		FM3032	Quantitative Finance	3	45 L				X
	FM 2011	FM3034	Financial Mathematics III	2	20 L 20 P				X
		FM3012	Economics I for Finance and Insurance	3	45 L				O
Level III S2		AM3034	Distribution & Random Number Theory	3	30 L 30 P		O	O	O
		AM3036	Applied Graph Theory	3	30 L 30 P	O	O	X	
		AM3037	Mathematical Methods II	3	45 L	O	X		
		AM3038	Mathematical Modeling	4	120 P		X		
		PM3032	Group Theory	4	60 L	X			
		PM3034	Real Analysis II	3	45 L	X	X		X
		PM3035	Complex Analysis	4	60 L	X			
		PM3037	Topology II	3	45 L	X			
		PM3038	Analysis in Several Dimensions	3	45 L	O			
		AM3084	Computational Mathematical Modeling	4	120 P			X	
	FM 2013	FM3033	Actuarial Mathematics II	3	45 L				X
		FM3035	Game Theory and Decision Theory	3	30 L 30 P				X
		FM3036	Computational Financial Modeling I	4	120 P				X
		IT3002	Database Systems	3	30 L 30 P			O	
		IT3007	Data Structures & Algorithms	3	30 L 30 P			X	
Level III		EC 3031	Community Service	4*	120 P	▪	▪	▪	▪

X : Core Courses O: Elective Courses ▪: Compulsory Courses

L: Lectures P: Practical/Labs * Will not be considered when calculating GPA

B.Sc. Honours Research Oriented Level IV

Level & Semester	Prerequisites	Course Unit	Title	Credit Value	Hours	BSc Honors Degree in			
						Mathematics	Applied Mathematics	Computational Mathematics	Mathematical Finance
Level IV S1		AM 4031	Applied Research Project	8	240 P		X		
		AM 4032	Advanced Optimization	3	45 L	O	O	O	O
		AM 4033	Non-Linear Programming	3	45 L	O	O	O	O
		AM 4034	Computational Fluid Dynamics	3	90 P		X		
		ST 4031	Stochastic Processes and Applications	3	45 L		O	O	O
		PM 4031	Research Project	8	240 P	X			
		PM 4032	Commutative Algebra	4	60 L	X			
		PM 4034	Measure Theory and Integration	4	60 L	X			
		PM 4036	Topological Spaces	4	60 L	O			
		AM 4081	Computational Mathematics Research Project	8	240 P			X	
		AM 4082	Computational Methods and Scientific Computing II	3	90 P			X	
	FM 3012	FM 4007	Economics II for Finance and Insurance	3	45 L				O
		FM 4031	Financial Mathematics Research Project	8	240 P				X
	FM 3033	FM 4032	Actuarial Mathematics III	3	45 L				X
		IT 4004	Advanced Database Systems	3	30 L 30 P			X	
Level IV S2		AM 4036	Fuzzy Modeling	4	120 P		X		
		AM 4037	Applied Functional Analysis	3	45 L		X		X
		AM 4038	Stochastic Calculus	3	30 L 30 P	O	O		O
		PM 4033	Field Theory and Galois Theory	4	60 L	X			
		PM 4035	Functional Analysis	4	60 L	X			
		PM 4037	Differential Geometry	4	60 L	O			
		PM 4038	Number Theory	4	60 L	O			
		AM 4083	Fuzzy Analytics	4	120 P			X	
		AM 4084	Unconventional Computing	3	45 L			O	
	FM 4032	FM 4033	Actuarial Mathematics IV	3	30 L 30 P				X
		FM 4034	Computational Financial Modeling II	4	120 P				X
Level IV		EC 4031	Industrial Training	4*	120 P		O	O	O

X : Core Courses   O: Elective Courses   ▪: Compulsory Courses

L: Lectures   P: Practical/Labs   * Will not be considered when calculating GPA

B.Sc. Honours Industrial Oriented Level III & IV

Level & Semester	Prerequisites	Course Unit	Title	Credit Value	Hours	Core or Elective
Level III S1		AM 3031	Mathematical Methods I	3	45 L	X
		FM 3032	Quantitative Finance	3	45 L	X
		MS 3011	Accounting for Finance	3	45 L	X
		FM 3012	Economics I for Finance and Insurance	3	45 L	X
		IT 3004	E- Commerce	2	20L 20P	O
		ST 3006	Regression Analysis	2	30L	O
		MS 3006	General Management	2	20L 20P	O
Level III S2		MS 3007	Strategic Human Resource Management	2	20L20P	O
		FM 3006	Insurance Market and Products	3	30L 30P	X
	FM 3032	FM 3035	Game Theory and Decision Theory	3	30 L 30 P	O
		FM 3008	Case Study in Finance	4	120 P	X
Level III		EC 3031	Community Service	4*	120 P	▪
Level IV S1	FM 3012	FM 4007	Economics II for Finance and Insurance	3	45L	O
	FM 3008	FM 4008	Case Study in Insurance	3	90 P	O
		MS 4003	Strategic Decision Making	3	30L 30 P	X
	FM 3008	MS 4005	Professional Development in Finance & Insurance	3	30L 30 P	X
	MS 3011	MS 4004	Statement Analysis	3	30L 30 P	X
Level IV S2	MS 4005	MS 4006	Entrepreneurship in Insurance & Finance	3	30L 30 P	X
		FM 4010	Industrial Training	6	180 P	X
		FM 4011	Industrial Research Project	6	180 P	X

X : Core Courses O: Elective Courses ▪: Compulsory Courses

L: Lectures P: Practical/Labs * Will not be considered when calculating GPA

AM 1011 Fundamental Applied Mathematics (30 L, 2C)

Rationale: The purpose of this course is to provide essential concepts needed to learn applied mathematics at the undergraduate level.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Relate real problems to Boolean satisfiability.
- Construct Boolean logic circuits to produce given outputs.
- Compare growth rates of functions.
- Simplify Boolean expressions.

Course Content:

Boolean expressions and functions: truth tables and applications, Boolean circuits, Boolean satisfiability problem and applications

Basic structures: set operations, computer representation of sets, Cartesian product, relations, functions, matrices with basic matrix operations, determinants, sequences and series, difference equations

Growth of functions: factorial, exponential and logarithmic functions, Big-O and little-o notations with respective estimates of functions

Introductory calculus: boundedness, computation of limits, definition of continuity, differentiability, Taylor series representation, functions of two variables, plotting functions with computational tools, applications of mean value theorem, partial differentiation

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Rosen, K.H. and Krithivasan, K. (2012). *Discrete Mathematics and its Applications: with Combinatorics and Graph Theory*. Tata McGraw-Hill Education.
2. Rosenbaum, R. A. and Johnson, G. P. (1984). *Calculus: Basic Concepts and Applications*. Cambridge: Cambridge University Press.
3. Kreyszig, E. (2006). *Advanced engineering mathematics*. New York: John Wiley & Sons.

AM 1012 Vector Calculus (30L, 2C)

Rationale: This course unit provides fundamental knowledge on vectors to facilitate problem solving in the physical sciences.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Solve problems in vector algebra and vector calculus.
- Calculate physical entities such as flux, divergence and curl.
- Apply Stoke's theorem and Green's theorem.

Course Content:

Introduction to vectors: definitions of vectors, scalars, basic properties of vectors, scalar, vector, triple scalar and triple vector products, applications of vectors to geometry (vector equations of lines, planes etc.)

Differentiation of vector-valued functions: geometric interpretation of the derivative, gradient of scalar functions, geometric interpretation of the grad operator, divergence and curl of vector fields, double operators, physical interpretation of irrotational and solenoidal vector fields

Integration of vector-valued functions: line integrals, surface and volume integrals, divergence theorem, Stoke's theorem, Green's theorem.

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Karunatilleke, A.D.W. and Golochtchapova, T. (2012). *3D Vectors : Algebra, Differentiation and Integration.* 2nd ed.
2. Davis, H.F. and Arthur David Snider. (2000). *Introduction to vector analysis*. Dubuque, Ia: Wm. C. Brown Publishers.
3. Spiegel, M.R. (1974). *Schaum's outline of theory and problems of vector analysis and an introduction to tensor analysis. SI metric ed.* New York, Etc.: Mcgraw-Hill.

AM 1013 Differential Equations I (30 L, 2C)

Prerequisite: AM 1011

Rationale: Mathematical formulation of physical laws such as conservation of mass, momentum and energy results in an ordinary differential equation or a system of such equations. This course helps to understand real-world problems leading to differential equations and their solutions.

Intended Learning Outcomes:

By the end of the course, students should be able to

- Identify real-world problems leading to differential equations.
- Solve elementary differential equations and analyse their solutions.
- Interpret the solutions of differential equations in real life problems.

Course Content:

Introduction to ODEs: continuity, differentiability and smoothness of a function, ordinary differential equation (ODE), solution of an ODE

First order ODEs: separable equations, linear equations, exact equations, Bernoulli's equation, existence and uniqueness of a solution of an ODE

Second order linear ODEs: constant-coefficient equations, complete primitive, complementary function and particular integral, applications to harmonic oscillator with and without damping, underdamping critical damping and overdamping, resonance, variable coefficient second order linear ODEs

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Ahmad, S. and Ambrosetti, A. (2015). *A textbook on ordinary differential equations*. Cham: Springer Verlag.
2. Braun, M. (1995). *Differential equations and their applications : an introduction to applied mathematics*. New York ; London: Springer-Verlag.
3. Bronson, R., Costa, G.B. and Bronson, R. (2006). *Schaum's outline of differential equations*. New York: McGraw-Hill.

AM 1014 Applied Linear Algebra (30 L, 2C)

Rationale: The purpose of this course is to provide a concrete introduction to the concepts in linear algebra in an application perspective.

Prerequisites: AM 1011

Intended Learning Outcomes:

By the end of the course, students should be able to

- Geometrically interpret the matrix-vector product, some properties of determinants, subspaces of R^1, R^2 and R^3 and the role of real eigenvalues.
- Relate matrix inversion to solving linear systems and matrices to linear transformations.
- Identify uniquely solvable linear systems.
- Apply the rank-nullity theorem to solve problems.
- Apply the diagonalization to evaluate matrix exponentials.
- Compute the eigenspectra of matrices.
- Determine the span of a given set in R^n.
- Determine the dimensions of a given subspace of R^n.

Course Content:

Systems of linear equations: row reduction and echelon forms, vector equations and matrix equation $Ax = b$, solution sets of linear systems and their properties

Vector subspaces: linear combinations, span, linear independence, basis, applications to linear systems, R^n as a vector space, subspaces of R^n, dimension of a vector space, null-space, column space, rank, nullity, rank nullity theorem.

Linear transformations: matrices as linear transformations, matrix operations, inverse of a matrix, characterization of invertible matrices, determinants, properties of determinants, Cramer's rule, volume and linear transformations, coordinates, change-of-base matrix

Eigenvalues and eigenvectors: eigenvectors and eigenvalues of a linear transformation, characteristic equation, diagonalization of matrices, applications

Introduction to inner products

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Halmos, P.R. (2017). *Finite dimensional vector spaces*. Mineola, Ny: Springer.
2. Lay, D.C., Lay, S.R. and Mcdonald, J. (2011). *Linear algebra and its applications*. Harlow: Pearson Education Limited.

AM 1015 Computational Mathematics I (60 P, 2C)

Prerequisites: None

Rationale: This course is intended to provide the students a hands-on experience in mathematical modelling of real-world problems and to direct the students towards selecting and implementing appropriate computational techniques in order to find solutions.

Intended Learning Outcomes:

By the end of the course, students should be able to
- Describe real world phenomena in mathematical jargons.
- Design appropriate mathematical models for real-world problems.
- Develop suitable algorithms and computational programs to implement and simulate the developed models.
- Compare and validate simulation results.

Course Content:

Practical-oriented sessions are conducted covering following areas in applied mathematics with suitable mathematical programming language/s such as MATLAB/MAPLE/Octave:

Elementary ordinary differential equations for real world problems: growth models, logistic equation, power law, Gompertz model, Richards growth model, Weibull growth model, Janoschek growth model and Morgan-Mercer-Flodin growth model, Applications of such models.

Method/s of Evaluation:

Continuous practical assessment: 50%
End of semester practical exam: 50%

Suggested References:

1. Bellomo, N., De Angelis, E. and Delitala, M. (2007). *Lecture notes on Mathematical Modelling in applied sciences*. Torino, Italy.
2. Murray, J.D. (2013). *Mathematical biology. I, An introduction*. New York: Springer-Verlag.
3. Othmer, H.G., Adler, F.R., Lewis, M.A. and Dallon, J.C. (1997). *Case Studies in Mathematical Modeling--ecology, Physiology, and Cell Biology*. Englewood Cliffs, NJ: Prentice Hall.

AM 1108: Mathematics for Biological Sciences (30L, 2C)

Rationale: This course is intended to introduce basic mathematical applications in Biology and Chemistry.

Prerequisites: None.

Intended Learning Outcomes:

By the end of the course, students should be able to

- Recall basic mathematical concepts, notations and some properties such as sets and their operations, numbers and law of indices, absolute value and their inequalities.
- Define real functions and function types.
- Find the inverse of a function, composition of two functions and the limit of a function.
- Apply differentiation and integration techniques on functions of a single variable.
- Compute first and higher order partial derivatives of functions of two or three variables.
- Formulate and solve problems in biology and chemistry.
- Represent complex numbers algebraically and geometrically.

Course Content:

Basic algebra: elementary set theory, numbers and law of indices, absolute value and their inequalities, introduction to complex numbers

Basic trigonometry: trigonometric functions and their inverse functions. Graphs of Sine, Cos and Tan functions. Various identities with trigonometric functions

Vectors and Matrices: addition, scalar multiplication and dot product of vectors. addition, scalar multiplication, multiplication and transpose of matrices, determinants, inversion of square matrices

Calculus: limits, differentiation, notion of a function, domain and range, composition of functions, even and odd functions, derivatives of algebraic, exponential and logarithmic functions, trigonometric functions and their inverses, introduction to partial differentiation, graphical interpretations of derivatives, maxima and minima, integration, linear first order differential equations with their applications to biology and chemistry

Method/s Of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. *Mathematics for Chemistry and Biology-Course Guide* (Open University of Sri Lanka).
2. Tebbutt, P. (1994). *Basic mathematics for chemists*. Chichester etc: Wiley.
3. Arya, J.C. and Lardner, R.W. (1979). *Mathematics for the biological sciences* (No. Sirsi) a402146). Prentice-Hall.
4. Gentry, R.D. (1978). *Introduction to Calculus for the Biological and Health sciences*. Addison-Wesley.

PM 1011 Foundations of Mathematics (30 L, 2C)

Rationale: A meaningful transition from secondary school mathematics to university mathematics requires students to know the methods of proof and their logical foundation, the difference between axiomatic approaches and the naïve approach in set theory, and essential set theoretic and functional concepts. This course provides the required knowledge and skills, and highlights the importance of writing clear and precise proofs.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Recognize statements and their negations, and find their truth values.
- Construct and interpret truth tables for statements.
- Correctly use algebra of statements and show the logical equivalence of statements.
- Recognize and analyze the use of quantifiers.
- Use logical analysis to determine the structure of a statement to be proved.
- Use the structure of the statement to structure an argument.
- Use correct grammar, punctuation, spelling and sentence structure for writing in English.
- Use accepted English mathematical terminology and idioms.
- Write with the mathematical voice including acceptable mathematical syntax, diction, punctuation, etc.
- Recognize the importance of writing clear and precise proofs
- Recognize the importance of communicating effectively in mathematics in both written and oral forms.
- Explain and use different methods of proofs in mathematics.
- Explain the difference between axiomatic approaches and the naïve approach in set theory.
- Explain and use essential set theoretic concepts.
- Manipulate union and intersection operators, including applications of De Morgan's Laws.
- Recognize relations and equivalence relations and construct equivalence classes.
- Recognize and apply properties of relations.
- Recognize when a relation is a function, and explain the properties of injective, surjective and bijective functions.
- Apply operations of functions including composing and inverting and solve problems.
- Prove that sets have the same cardinality by exhibiting a bijective function.

Course Content:

Logic: statements; and, or, not connectives; truth tables for statements; logical equivalence; conditional statements; biconditional statements; negation of statements; algebra of statements; quantifiers.

Methods of Proofs: direct proof; proof by contradiction; proof by cases; proof by contraposition; proof by mathematical induction; proof by strong mathematical induction; proof by well ordering principle; disproof by counterexample.

Sets: Russell's paradox; notations; equality of sets; subsets; universal sets; power set; partition of a set; set operations; algebra of sets; the Principle of Inclusion and Exclusion; arbitrary unions and intersections; Cartesian products; categorical statements, categorical syllogisms and Venn diagrams;

Relations: definition and notations; equivalence relations and equivalence classes.

Functions: definition and notations; domain, range, image and preimage; injective, surjective and bijective functions; operations on functions; composition of functions; inverse functions.

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Hammack, R.H. (2018). *Book of proof*. Virginia: Virginia Commonwealth University.
2. Krantz, S. G. (2017). *The Elements of Advanced Mathematics*, 4th ed, CRC Press, Boca Raton.
3. Krantz, S. G. (2017). *A Primer of Mathematical Writing: Being a Disquisition on Having Your Ideas Recorded, Typeset, Published, Read, and Appreciated*, 2nd ed, American Mathematical Society, Providence.

PM 1012 Introduction to Number Theory (30L, 2C)

Rationale: This introductory course in number theory gives a smooth transition from school mathematics to university mathematics by providing a concrete experience in problem solving and algebraic reasoning. It covers introductory level topics in number theory with examples simple enough to understand, yet powerful enough to challenge students.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Explain basic concepts in number theory such as unique factorization, greatest common divisor, least common multiple and Euclidean algorithm, and use them to solve problems.

- Derive the general solution to basic Diophantine equations and congruence equations and use them to solve problems.
- Explain key ideas in the Chinese remainder theorem and use them or the theorem to solve problems.
- Explain key ideas in the Fermat's little theorem and use them or the theorem to solve problems, including applications to Wilson's theorem and the RSA algorithm.

Course Content:

Basic properties of natural numbers and integers: divisibility, prime numbers and unique factorization, division algorithm, greatest common divisor and least common multiple, relatively prime integers, Euclidean algorithm, Diaphontine equation $ax + by = c$.

Congruences: basic properties of congruences, Congruence equations, Chinese remainder theorem and its applications. Fermat's little theorem, Pseudo primes, Wilson's theorem, Fermat-Kraitchik factorization, RSA algorithm and its proof.

Further topics: Pythagorean triples, Fermat's last theorem, Prime numbers and their distribution.

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Burton, D. M. (2011). *Elementary number theory*, 7th ed, McGraw-Hill, New York.
2. Silverman, J. A. (2012). *A friendly introduction to number theory*, 4th ed, Pearson, Upper Saddle River.

PM 1013 Basic Analysis I (30L, 2C)

Rationale: This course is the first of a sequence of three courses which formulate basic ideas of calculus in a mathematically rigorous manner. It encourage students to develop a sense of why rules in mathematics work in general, their limitations and in what contexts they are applicable.

Prerequisites: PM 1011

Intended Learning Outcomes:

By the end of the course, students should be able to

- Explain and justify basic properties of real numbers.
- Investigate whether a given set is an interval.

- Identify and justify supremum's and infimums of bounded sets.
- Explain the definition of the convergence of a sequence and recognize convergence or divergence of a sequences.
- Explain the definition of a limit of a function and recognize the existence or non-existence of a limit of a given function at a point.
- Explain the definition of the continuity of a function at a point and identify points at which a given function is continuous and discontinuous.
- Solve problems by first principles.
- Explain key ideas of limit and continuity theorems and apply them and theorems to solve problems.

Course Content:

Properties of Real Numbers: Rational and Irrational numbers, algebraic properties, order properties and inequalities, Modulus and its properties, Intervals, Bounded and unbounded subsets of real numbers, completeness of the real numbers, least upper bound (supremum) and greatest lower bound (infimum), Archimedean property and its consequences, denseness of rational and irrational numbers in the set of real numbers

Sequences: Limit of a sequence (definition), convergence and divergence of a sequence, uniqueness of limit, limit laws for sequences, squeeze theorem, monotone sequences, bounded and unbounded sequences, boundedness of a convergent sequence, infinite limits of sequences, convergence of monotonic bounded sequences

Functions: Limits of functions (definition), uniqueness of limit, limit laws, squeeze theorem for limits of functions, one sided limits, infinite limits and limits at infinity, definition of continuity at a point, relationship between limit and continuity, one sided continuity, functions continuous on a set, algebraic operations on continuous functions

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Fitzpatrick, P. M. (2006). *Advanced Calculus*, 2nd ed, American Mathematical Society, Providence.
2. Lay, S. R. (2014). *Analysis with an Introduction to Proof*, 5th ed, Pearson, Upper Saddle River.
3. Protter, M. H. (1998). *Basic elements of Real Analysis*, Springer-Verlag, New York.
4. Mattuck, A. (1999). *Introduction to Analysis*, Prentice Hall, Upper Saddle River.
5. Ross, K. A. (2013). *Elementary Analysis, The theory of calculus*, 2nd ed, Springer, New York.

PM 1014 History as Motivation for Mathematics (30L, 2C)

Prerequisites: None

Rationale: The rigorous logical approach in ascertaining the truth of mathematical statements in mathematics courses at the university can be appealing to mathematically inclined students but the historical development of and motivation for mathematical ideas underlying these mathematical statements can be inspiring to students in general. This course provides the historical development of and motivation for some key mathematical ideas taught in undergraduate mathematics courses.

Intended Learning Outcomes:

By the end of the course, students should be able to

- Explain how social, cultural, and historical factors influenced the development of the key ideas in mathematics covered in the course.
- Identify a variety of theorems and mathematicians and explain how they shaped the history of mathematics.
- Read and comprehend historical mathematical sources.
- Research a mathematician or a mathematical concept, drawing on historical sources, to illustrate the ways in which social, cultural, and historical factors shaped the mathematical ideas of the mathematician or the mathematical concept.
- Appreciate mathematics for its creative and insightful development of the concepts.

Course Content:

Early Number Systems and Symbols: primitive counting: notches as tally marks, the Peruvian Quipus; number systems of the Egyptians: Hieratic and Hieroglyphic representations; number systems of the Babylonians: Cuneiform script, sexagesimal place value system.

Mathematics in Early Civilizations: Egyptian mathematics: doubling and halving process, the unit fraction table; Babylonian Mathematics: tables of reciprocals, solving the quadratic equation, “cut-and-paste” geometry, square roots and the Pythagorean Theorem, Plimpton 322; linear equations and proportional reasoning, the false position method, approximating the area of a circle, discovery of irrationality by Hippasus of Metapontum.

Three Construction Problems of Antiquity: the appearance of demonstrative mathematics, Hippocrates’ quadrature of the lune, squaring the circle, doubling the cube, trisecting an angle.

Euclid’s Proof of the Pythagorean Theorem: Book I of the *Elements*, definitions, postulates, common notions, parallel postulate (postulate 5) and related topics, propositions I.47 and I.48.

Mathematical Proof: concept, history and rigor of proof, concept of theorem, L. E. J. Brouwer and proof by contradiction, Errett Bishop and constructive analysis.

Insolvability of the Quintic and Higher Degree Equations in Radicals, the Story: invention of printing, founding of the great universities, Cardan's *Ars Magna* and Cardan's solution of the cubic equation, Bombelli and imaginary roots of the cubic, Ferrari's solution of the quartic equation, the story of the proof of insolvability of the quintic and higher degree equations in radicals by Ruffini, Abel, and Galois.

Development of Calculus, a Brief Account: Zeno's Paradoxes, the method of exhaustion, *the Method* of Archimedes, Archimedes' determination of the area of a circle, Cavalieri's method of indivisibles, Evangelista Torricelli and Gabriel's Horn, Leibniz's "characteristic triangle", Newton's fluents and fluxions, Berkeley's criticism of infinitesimals.

Convergence of Series, the Struggle: Grandi's series, Leibniz's probabilistic argument on the sum of Grandi's series, Euler on Grandi's series and power series.

Counting the Infinite, the Controversies: Galileo's Paradox, mathematics of the nineteenth century, denumerability of the rationals, non-denumerability of the continuum, Kronecker's and Poincare's criticisms of Cantor's Theory of Infinite Sets.

Point-Set Topology, the Beginnings: Cantor's concept of a limit point, Frechet's metric spaces.

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Burton, D. M. (2011). *The History of Mathematics: AN INTRODUCTION*, 7th ed, McGraw-Hill, New York.
2. Dunham, W. (1991). *Journey Through Genius THE GREAT THEOREMS OF MATHEHAMTICS*, Penguin Books USA, New York.
3. Katz, V. J. (2009). *A History of Mathematics, An Introduction by Victor J. Katz,* 3rd ed, Addison-Wesley, Boston.
4. Von Fritz, K. (1945). 'The Discovery of Incommensurability by Hippasus of Metapontum', *Annals of Mathematics*, vol. 46, no. 2, pp. 242 -264.
5. Kline, M. (1983). 'Euler and Infinite Series', *Mathematics Magazine*, vol. 56, no. 5, pp. 307-314.
6. Krantz, S.G. (2007). *The history and concept of mathematical proof* (Vol. 5). February.
7. Kleiner, I. (1991). 'Rigor and Proof in Mathematics: A Historical Perspective', *Mathematics Magazine*, vol. 64, no. 5, pp. 291-314.

FM 1011 Financial Mathematics I (30L, 2C)

Rationale: This course explores the theoretical aspects of finance, provides a guidance for valuation and deals with introductory-level applications of financial mathematics.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to
- Recall the notion of impotency of time value.
- Compute present and future values.
- Model and compute different cash flows.
- Analyze and value simple financial instruments.

Course Content:

Interest rates: review finance field, interest rate, simple and compound interest rates, rate of discount, force of interest

Time values: time value of money, present value, future value, discounting, compounding, effective rate of return (EAR)

Annuities: basic annuity valuation, annuity immediate, annuity due, perpetuity, discounted cash flow analysis, NPV, internal rate of return (IRR), interest rate on fund

Computation: financial functions in Excel and their applications

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Ross, S.A., Westerfield, R. and Jaffe, J.F. (2013). *Corporate finance*. New York, Ny: Mcgraw-Hill/Irwin.
2. Kellison, S.G. (2014). *The theory of interest*. Boston: Mcgraw-Hill Irwin.

FM 1012: Mathematical Methods for Finance I (30L, 2C)

Rationale: This course unit is introduced to provide an overview of essential mathematical methods helpful in solving real -world problems.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to
- Explain the concept of solution of an ordinary differential equation and a difference equation.
- Identify finance-related and other real-world problems which can be modelled by differential equations.
- Solve first and second order ordinary differential equations and difference equations by analytical methods.

Course Content:

First order ODEs: ordinary differential equations (ODEs) with examples in financial applications. First order ordinary differential equations, classical solution methods

Second order ODEs: second order linear constant coefficient differential equations, classical solution methods

Difference equations: introduction to first and second order constant coefficient difference equations, classical solution methods, stability of solutions, systems of linear difference equations. application to finance

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1 Boyce, W.E. and DiPrima, R.C.(2012). *Elementary differential equations* (Vol. 6). New York: Wiley.
2 Kreyszig, E. (2006). *Advanced engineering mathematics*. New York: John Wiley & Sons.
3 Goldberg, S. (1986). *Introduction to difference equations : with illustrative examples from economics, psychology, and sociology*. New York: Dover.

FM 1013 Linear Programming (30L, 2C)

Rationale: This course provides an introduction to the basic areas of linear programming (LP). The course will cover modelling, analysis and computational techniques concerning linear programming.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Develop a linear programming model from a given problem description.
- Apply graphical and simplex methods to solve linear programming problems.
- Recognize special cases such as degeneracy, alternative optima, unboundedness and infeasibility in LPs.
- Analyze the effect on optimal solution of the LP model due to variations in the input parameters.
- Construct the dual problem from the primal problem.
- Use the duality theory to solve LP problems.
- Solve LP problems using an appropriate computational tool such as TORA.

Course Content:

Basics: Formulation of linear programming problems, solving LP problems of two variables using the graphical method

Simplex method: application of the simplex algorithm, special cases in the simplex method such as degeneracy, alternative optima, unbounded solution and infeasible solution

Sensitivity analysis: sensitivity analysis using graphical and simplex methods, artificial variable techniques: big-M method, two-Phase simplex method

Duality: dual LP problem, duality theorem and its consequences, dual simplex method

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. A, T.H. (2004). *Operations research : an Introduction*. New Delhi: Prentice Hall Of India.
2. Winston, W.L., Venkataramanan, M.A. and Goldberg, J.B. (2003). *Introduction to mathematical programming.* Pacific Grove, Calif. ; London: Thomson/Brooks/Cole.
3. Hillier, F.S. and Lieberman, G.J. (1995). *Introduction to operations research*. New York, N.Y.: Mccraw-Hill.

FM 1014 Computational Financial Mathematics I (60 P, 2C)

Prerequisites: None.

Rationale: This course is intended to provide the students a hands-on experience in mathematical modelling of real-world problems and to direct the students towards selecting and implementing appropriate computational techniques in order to find solutions.

Intended Learning Outcomes:

By the end of the course, students should be able to

- Describe real world phenomena in mathematical jargons.
- Design appropriate mathematical models for financial and other problems.
- Develop suitable algorithms and computational programs to implement and simulate the developed models.
- Compare and validate simulation results.

Course Content:

Practical-oriented sessions are conducted covering following areas in applied mathematics with suitable mathematical programming language/s such as MATLAB/MAPLE/Octave:

Elementary ordinary differential equations for real world problems: growth models, logistic equation, power law, Gompertz model, Richards growth model, Weibull growth model, Janoschek growth model and Morgan-Mercer-Flodin growth model, Applications of such models.

Method/s of Evaluation:

Continuous practical assessment: 50%
End of semester practical exam: 50%

Suggested References:

1. Bellomo, N., De Angelis, E. and Delitala, M. (2007). *Lecture notes on Mathematical Modelling in applied sciences*. Torino, Italy.
2. Murray, J.D. (2013). *Mathematical biology. I, An introduction*. New York: Springer-Verlag.
3. Othmer, H.G., Adler, F.R., Lewis, M.A. and Dallon, J.C. (1997). *Case Studies in Mathematical Modeling--ecology, Physiology, and Cell Biology*. Englewood Cliffs, NJ: Prentice Hall.

MS 1011 Computing For Finance (30P, 1C)

Rationale: This course unit is introduced to provide an overview of a computational software and to use it for introductory financial computations.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Relate manual computations to computer inputs and commands.
- Identify necessary computational tools to solve a problem.
- Write introductory level computer algorithms.
- Plot graphs of functions using a computational software and interpret them.
- Develop optimization models and solve by computational tools.
- Construct introductory computational models to solve real problems.
- Validate introductory models through computations.
- Compute portfolio parameters using computational software.

Course Content:

Use of computational tools to optimize functions subject to certain constraints. Use of the computational tools to analyse and solve specific problems that come up in areas like management, finance, economics and applied mathematics in general.

Method of Evaluation:

Continuous assessments: 100%

Suggested References:

1. Kwon, R.H., 2013. *Introduction to linear optimization and extensions with MATLAB®*. CRC Press.

MS 1012 Mathematical Economics (30L, 2C)

Rationale: This course unit in intended to give an overview of mathematical applications in economics.

Prerequisites : None

Intended Learning outcomes:

By the end of the course, students should be able to

- Describe basic microeconomic and macroeconomic models.
- Analyze and extend these economic models.

Course Content:

Introduction to economics, role of mathematics in economics, general study of demand, supply and equilibrium.

Static analysis of market models and selected macroeconomic models. Effect of taxation on static market models.

Dynamic analysis in continuous and discrete time of market models and selected macroeconomic models. Effect of taxation on dynamic market models.

Welfare economics: consumer's and producer's surpluses

Elasticity and other economic concepts: elasticity of demand and supply, point and cross elasticities. Analysis of single product functions and joint products functions {cost, revenue, profit, etc.}.

Optimization of single product functions and joint products functions { cost, revenue and profit functions}.

Utility functions: introduction, derivation, maximizing with and without budget constraints ; derivation of demand functions, marginal rate of substitution, indifference curves and contract curves (Edgeworth box).

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Chiang, A.C. and Wainwright, K. (2013). *Fundamental methods of mathematical economics*. New Delhi, India: Mcgraw Hill Education (India) Private Limited.
2. K Holden and Alan Wilfred Parson. (1992). *Introductory mathematics for economics and business*. Houndmills: Palgrave Macmillan.

AM 2011: Differential Equations II (30L, 2C)

Rationale: This course is to introduce systems of first order differential equations, second order ordinary differential equations (variable coefficient) and difference equations for modelling physical and other phenomena.

Prerequisites: AM1013

Intended Learning Outcomes:

By the end of the course, students should be able to

- Apply systems of first order differential equations to scientific problems.
- Compute the characteristic polynomial, eigenvalues and eigenspace, eigenvectors as well as the geometric and algebraic multiplicities of an eigenvalue and apply it to find the solutions of systems.
- Investigate the qualitative behaviour of systems of differential equations.
- Solve linear second order ordinary differential equations with variable coefficients using analytical methods.
- Find power series solutions of several differential equations.
- Find the ordinary, singular, regular singular and irregular singular points.

Course Content:

Higher order ODEs: real examples of systems of first order ordinary differential equations, transformation of higher order ordinary differential equations to a system of first order ODE' s; fundamental solution, qualitative theory of ODEs (stability of linear systems)

Series solutions: linear equations of the second order where the coefficients are functions of the independent variable, ordinary points; singular points, regular singular points; solution in series

Difference equations: complementary functions and particular solutions o difference equations

Method/s Of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Boyce, W.E. and DiPrima, R.C.(2012). *Elementary differential equations* (Vol. 6). New York: Wiley.
2. Ross, S.L. (1974). *Differential equations*. New York Wiley.
3. Kreyszig, E. (2006). *Advanced engineering mathematics*. New York: John Wiley & Sons.
4. Goldberg, S. (1986). *Introduction to difference equations : with illustrative examples from economics, psychology, and sociology*. New York: Dover
5.

AM 2012: Linear Programming (30L, 2C)

Rationale: This course provides an introduction to the basic areas of linear programming. The course will cover modeling, analysis, and computational techniques concerning linear programming.

Prerequisites: AM 1014

Intended Learning Outcomes:

By the end of the course, students should be able to

- Develop a linear programming model from a given problem description.
- Apply graphical and simplex methods for solving linear programming problems.
- Recognize special cases such as degeneracy, alternative optima, unboundedness and infeasibility in LPs.
- Analyze the effect on optimal solution of the LP model due to variations in the input parameters.

Course Content:

Basics: Formulation of linear programming problems, solving LP problems of two variables using the graphical method

Simplex method: the simplex algorithm, special cases in the simplex method such as degeneracy, alternative optima, unbounded solution and infeasible solution

Sensitivity analysis: sensitivity analysis using graphical and simplex methods, artificial variable techniques: big-M method, two-Phase simplex method

Methods of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. A, T.H. (2004). *Operations research : an Introduction*. New Delhi: Prentice Hall Of India.
2. Winston, W.L., Venkataramanan, M.A. and Goldberg, J.B. (2003). *Introduction to mathematical programming.* Pacific Grove, Calif. ; London: Thomson/Brooks/Cole.
3. Hillier, F.S. and Lieberman, G.J. (1995). *Introduction to operations research*. New York, N.Y.: Mccraw-Hill.

AM 2013 Numerical Analysis (30 L, 2C)

Rationale: Most of the mathematically formulated real-life problems are not analytically solvable, though the existence and uniqueness of a solution can be established via mathematical analysis. This course helps to find approximate solutions to such problems.

Prerequisite: AM 2011

Intended Learning Outcomes:

By the end of the course, students should be able to

- Recall basic concepts of numerical methods.
- Apply mathematical methods to construct numerical methods.
- Select an appropriate numerical method to solve a given mathematical problem, depending on the requirements of an approximate solution.
- Demonstrate the consistency, stability and convergence of numerical methods.
- Find error bounds for numerical solutions.

Course Content:

Mathematical preliminaries and error analysis: Taylor’s theorem and its relation to numerical methods, applications of sequences and series in numerical methods

Numerical methods for nonlinear equations: bisection and Newton-Raphson methods with convergence analysis, fixed point iteration with its application to nonlinear equations, convergence of fixed point iteration

Mathematical problems leading to system of linear equations, numerical methods for solving linear systems of equations.

Numerical method for initial value problems: Euler’s method and higher order Taylor’s series methods, Runge-Kutta methods, order of accuracy

Interpolation and extrapolation: polynomial interpolation, Lagrange interpolation, interpolation by linear, quadratic and cubic splines, numerical differentiation and integration, Richardson extrapolation

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Burden, R.L. and Faires, J.D. (1997). *Numerical Analysis*, Brooks. *Cole Pub*, *7*.
2. Kincaid, D., Kincaid, D.R. and Cheney, E.W., 2009. *Numerical analysis: mathematics of scientific computing* (Vol. 2). American Mathematical Soc.

AM 2014: Optimisation (30L, 2C)

Rationale: This course discusses both mathematical programming and game theoretic approaches in solving constrained optimisation problems of several variables and two-person zero-sum games.

Prerequisites: AM 2012

Intended Learning Outcomes:

By the end of the course, students should be able to

- Use additional simplex algorithms to solve general LPs.
- Use the duality theory to solve LP problems.
- Carry out the post-optimal (sensitivity) analysis.
- Recall the basics of non-linear programming models.
- Formulate, analyse and solve several unconstrained and constrained optimisation problems.
- Find the optimal solution of a two-person zero sum game

Course Content:

Simplex Algorithm: Two-phase, big-M, dual simplex and generalised simplex methods

Duality in linear programming: dual LP problem, duality theorem and its consequences

Sensitivity analysis in linear programming: algebraic sensitivity analysis – changes in the right-hand side, objective function, and the coefficients of constraints, addition of new variables and new constraints, deletion of variables and constraints

Game theory: Some basic terminologies, optimal solution of two-person zero-sum games, solution of mixed strategy games

Non-linear programming: unconstrained and constrained optimisation of functions of single and many variables and applications

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. A, T.H. (2004). *Operations research : an Introduction*. New Delhi: Prentice Hall Of India.
2. Winston, W.L., Venkataramanan, M.A. and Goldberg, J.B. (2003). *Introduction to mathematical programming.* Pacific Grove, Calif. ; London: Thomson/Brooks/Cole.
3. Hillier, F.S. and Lieberman, G.J. (1995). *Introduction to operations research*. New York, N.Y.: Mccraw-Hill

AM 2015 Computational Mathematics II (60 P, 2C)

Rationale: This course is intended to provide the students a hands-on experience in mathematical modelling of real-world problems and to direct the students towards selecting and implementing appropriate computational techniques in order to find solutions.

Prerequisites: AM 1015

Intended Learning Outcomes:

By the end of the course, students should be able to

- Describe several real world phenomena in mathematical jargons.
- Design appropriate mathematical models for selected real-world problems.
- Develop suitable algorithms and computational programs to implement and simulate the developed models.
- Compare and validate simulation results.

Course Content:

Practical-oriented sessions are conducted covering following areas in applied mathematics with mathematical programming language/s such as MATLAB/MAPLE/Octave:

Ordinary differential equations for interacting populations, discrete models for interacting population dynamics, complexity and stability, nonlinear models, competition models for limited resources, simple epidemic models and practical applications, optimisation models

Method/s of Evaluation:

Continuous practical assessments: 50%
End of semester practical exam: 50%

Recommended Reading:

1. Bellomo, N., De Angelis, E. and Delitala, M. (2007). *Lecture notes on Mathematical Modelling in applied sciences*. Torino, Italy.
2. Murray, J.D. (2013). *Mathematical biology. I, An introduction*. New York: Springer-Verlag.
3. Othmer, H.G., Adler, F.R., Lewis, M.A. and Dallon, J.C. (1997). *Case Studies in Mathematical Modeling--ecology, Physiology, and Cell Biology*. Englewood Cliffs, NJ: Prentice Hall.

PM 2011 Basic Analysis II (30L, 2C)

Rationale: This course is the second of a sequence of three courses which formulate basic ideas of calculus in a mathematically rigorous manner.

Prerequisites: PM 1013

Intended Learning Outcomes:

By the end of the course, students should be able to

- Explain the notion of a subsequence and use it to solve convergence or divergence problems of sequences.
- Apply theorems on sequences to construct the proofs of the Bolzano-Weierstrass theorem and the nested interval theorem.
- Explain limits and continuity in terms of sequences and use sequences to solve limit and continuity problems.
- Explain uniform continuity and investigate whether a given function is uniformly continuous or not.
- Construct and explain proofs of theorems about functions continuous on closed bounded intervals and use them to solve problems.

- Explain the concept of differentiability, identify points at which a function is differentiable or non-differentiable and justify assertions on differentiability and non-differentiability.

- Construct and explain proofs of differentiation theorems and use them to solve problems.

- Investigate properties of differentiable functions such as local extrema, monotonicity and convexity using first and second order derivatives and differentiation theorems.

Course Content:

Sequences: Subsequences, Convergence of a sequence in terms of subsequences, Bolzano-Weierstrass theorem, Nested interval theorem

Limits and Continuity: Limits and Continuity in terms of sequences, Uniform continuity, Definition and examples

Functions continuous on closed bounded intervals: Intermediate value theorem, Maximum-Minimum Theorem, Uniform Continuity of a function continuous on a bounded closed interval

Differentiability: Concept of Differentiability, Continuity and Differentiability, Differentiation Rules, Differentiating compositions and inverses, higher order derivatives, derivative and local extrema, Rolle's Theorem, Mean Value Theorem and its consequences, Cauchy Mean Value theorem, L'Hospital's rule, sign of derivative and monotonicity of differentiable functions, derivative and convexity

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Fitzpatrick, P. M. (2006). *Advanced Calculus*, 2nd ed, American Mathematical Society, Providence.
2. Mattuck, A. (1999*). Introduction to Analysis*, Prentice Hall, Upper Saddle River.
3. Lay, S. R. (2014). *Analysis with an Introduction to Proof*, 5th edn, Pearson, Upper Saddle River.
4. Protter, M. H. (1998) *Basic elements of Real Analysis*, Springer-Verlag, New York.
5. Ross, K. A. (2013). Elementary Analysis, The theory of calculus, 2nd edn, Springer, New York.

PM 2012 Basic Analysis III (30L, 2C)

Rationale: This course is the third of a sequence of three courses which formulates basic ideas of calculus in a mathematically rigorous manner.

Prerequisites: PM 2011

Intended Learning Outcomes:

By the end of the course, students should be able to

- Solve problems involving integrals, improper integrals and series by first principles.
- Explain the concept of Riemann integrability and identify integrable and non-integrable functions.
- Explain the relationship between differentiation and integration via the fundamental theorem of calculus.
- Construct and explain proofs of the theorems on integrals and use them to solve problems.
- Explain the convergence or divergence of improper integrals of all kinds.
- Investigate the convergence of improper integrals using comparison theorems and other results.
- Explain the convergence of a series and identify convergent and divergent series.
- Construct and explain proofs of convergence tests and apply them to investigate the convergence and divergence of series.
- Explain radius of convergence and interval of convergence of power series and use results on series to determine them.
- Construct and explain the proof of the Taylor's theorem and use it to obtain power series representations of functions.
- Define exponential, logarithmic and trigonometric functions and derive their properties.

Course Content:

The Riemann Integral: Partitions of a closed bounded interval, Upper and Lower Sums of a bounded function, Upper and lower integrals of a bounded function, Riemann integrability of a bounded function, integrability of a continuous function, Properties of the integral (linearity, additivity over intervals, monotonicity), antiderivatives, antiderivatives defined by integrals, Fundamental Theorem of Calculus, Integration by parts and change of variable rule

Improper Integrals: Convergence and divergence of improper integrals of all kinds (improper integrals of functions defined on unbounded intervals and improper integrals of functions unbounded at endpoints of bounded intervals) , Comparison Theorems for improper integrals, absolute and conditional convergence of improper integrals

Series: Sequence of partial sums and convergence of a series, geometric series and *p*-series, limit test (test for divergence), absolute and conditional convergence, alternating series, integral test, comparison and limit comparison tests, Root and Ratio Tests (with limits)

Power Series: Radius of Convergence and Interval of Convergence, Taylor's Theorem and Taylor Series

Elementary transcendental functions: The exponential function, logarithmic function, trigonometric functions, power series expansions of exponential, logarithmic and trigonometric functions

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Fitzpatrick, P. M. (2006). *Advanced Calculus*, 2nd ed, American Mathematical Society, Providence.
2. Mattuck, A. (1999*). Introduction to Analysis*, Prentice Hall, Upper Saddle River.
3. Lay, S. R. (2014). *Analysis with an Introduction to Proof*, 5th ed, Pearson, Upper Saddle River.
4. Protter, M. H. (1998). *Basic elements of Real Analysis*, Springer-Verlag, New York.
5. Ross, K. A. (2013). Elementary Analysis, The theory of calculus, 2nd ed, Springer, New York.

PM 2013 Introduction to Abstract Algebra (30 L, 2C)

Rationale: This course provides an introduction to algebraic structures, in particular to groups, which are central in modern mathematics and its applications. Students will learn that different mathematical structures (sets of mathematical objects with operations defined on them) are special cases of the same abstract structure which is defined by a set of axioms. The course will provide them with the skills of proving assertions based on the axioms and previously proved results. Recognizing that the obtained results are valid for all mathematical structures that satisfy the axioms will enable them to appreciate the advantage of the axiomatic approach.

Prerequisites: PM 1012

Intended Learning Outcomes:

By the end of the course, students should be able to

- Give examples of binary operations on sets and identify their properties.
- Define and give examples of groups, subgroups, cyclic groups, quotient groups and rings.
- Identify groups, subgroups, cyclic groups, quotient groups, rings and subrings.
- Derive and explain basic properties of groups, subgroups, cyclic groups, rings and subrings.
- Define cosets and explain important properties of cosets using examples.
- State and use Lagrange's theorem for finite groups.
- Define and give examples of group homomorphisms and isomorphisms.
- Investigate whether two groups are isomorphic.
- Derive and explain basic properties of homomorphisms.
- Construct and explain the proof of Cayley's Theorem and compute Cayley's representation explicitly.
- Use the classification theorem of finite abelian groups to list all abelian groups (up to isomorphism) of a given order.

Course Content:

Introduction to algebraic structures: Sets with operations: Binary operations and their properties: associativity, commutativity, identity and invertibility of elements; Examples.

Introduction to groups: Symmetries as groups, dihedral groups, permutation groups and other examples of groups; Definition of a group and proofs of basic properties of a group; Definition of a subgroup, examples and proofs of basic properties of subgroups; Cosets and their properties, Lagrange's Theorem, Normal subgroups ; Cyclic groups and cyclic subgroups: Examples and basic properties ; Definition of group homomorphisms and isomorphisms, Kernel, Properties of group homomorphisms, Quotient group and First Isomorphism Theorem; Group actions, examples and applications of group actions, Cayley's representation theorem ; Abelian groups and classification theorem.

Introduction to rings and fields: Definition of a ring and a field; Examples and proofs of basic properties of a ring. Zero divisors and integral domains. Definition of a subring, examples and basic properties.

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Fraleigh, J. B. (2002). *A First Course in Abstract Algebra*, 7th ed, Pearson, Upper Saddle River.

2. Rotman, J. J. (2005). *A First Course in Abstract Algebra*, 3rd ed, Pearson, Upper Saddle River.

FM 2011 Financial Mathematics II (30L, 2C)

Rationale: This course discusses pricing techniques of simple financial instruments.

Prerequisites: FM 1011

Intended Learning Outcomes:

By the end of the course, students should be able to

- Recall the pricing techniques.
- Design and compute loan repayment.
- Model the price of simple financial instruments.
- Analyze financial feasibility of simple projects.

Course Content:

General annuity valuation, applications of annuity based valuations, financial feasibility of real projects, modelling the profitability of the project, loan repayment methods, amortization schedules, sinking fund, bond valuation, zero coupon bond, stock valuation, introduction to insurance mathematics, financial functions in Excel and their applications

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Ross, S.A., Westerfield, R. and Jaffe, J.F. (2013). *Corporate finance*. New York, Ny: Mcgraw-Hill/Irwin.
2. Kellison, S.G. (2014). *The theory of interest*. Boston: Mcgraw-Hill Irwin.

FM 2012 Linear Algebra (30 L, 2C)

Rationale: This course provides the knowledge of fundamental concepts and essential theories in linear algebra which are used in the field of mathematical finance.

Prerequisites: None.

Intended Learning Outcomes:

By the end of the course, students should be able to

- Apply matrices as a mathematical tool to solve various kinds of problems.
- Work with problems of several variables by applying finite dimensional vector spaces and their properties.
- Relate linear transformation to matrices.
  Solve real problems using inner products.

Course Content:

Matrices: basic matrix operations, inverse of a matrix, determinates, solution of a system of linear equations, Cramer's rule, application to Markov chains, characteristic polynomial and Caley-Hamilton theorem, diagonalizability of matrices

Vector spaces: properties of vector spaces, subspaces, sums and direct sums, span and linear independence, bases and dimensions

Linear transformations: transformations on finite dimensional vector spaces, null-space and range, matrix representation of a linear transformation, invertibility of a linear transformation, rank-nullity theorem, coordinates and change of a basis in finite dimensional vector spaces

Inner product spaces; Inner products, norms, orthonormal bases, orthogonal complement and orthogonal projection, Gram-Schmidt process and QR factorization, quadratic forms

Method of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Poole, D.C. (2015). *Linear algebra : a modern introduction*. Stamford, Ct: Cengage Learning.
2. Lay, D.C., Lay, S.R. and McDonald, J. (2011). *Linear algebra and its applications*. Harlow: Pearson Education Limited.
3. Strang, G. (2016). *Introduction to linear algebra*. Wellesley, Ma: Cambridge Press.

FM 2013 Actuarial Mathematics I (30L, 2C)

Rationale: This course explores the theoretical aspects of random cash-flows particularly life insurance models and pricing of such models.

Prerequisites: FM 1011

Intended Learning Outcomes:

By the end of the course, students should be able to

- Describe the concept of actuarial present value.
- Compare life insurance policies.
- Evaluate actuarial present values.
- Model and compute future life time.
- Design and compute life insurance products.
- Apply actuarial evaluation techniques.

Course Content:

Introduction to actuarial concepts: valuation and actuarial valuation, importance of actuarial concepts and their applications in various finance fields

Introduction to insurance: survival distribution, mortality rate, life expectancy, life table, insurance and related models, applications of insurance models

Life annuity and related models: Applications of life annuity models, loss random variable and its applications in Insurance models, premiums determination methods and related problems

Method/s of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A., Nesbitt, C.J. and Al, E. (1997). *Actuarial mathematics*. Schaumburg (Illinois): The Society Of Actuaries.
2. Gerber, H.U. (1997). *Life insurance mathematics*. Berlin ; New York: Springer.

MS 2011 Numerical Methods for Finance (30 L, 2C)

Rationale: Most of the mathematically formulated financial market problems are not analytically solvable even though existence and uniqueness of a solution can be established via mathematical analysis. This course helps to find approximate solutions for such problems.

Prerequisite: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Describe basic concepts of numerical methods for finance.
- Construct numerical methods for financial problems.

- Identify appropriate numerical methods to solve a given financial mathematics problem, depending on the requirements of approximate solutions.
- Demonstrate the consistency, stability and convergence of numerical methods for finance.
- Find error bounds for numerical solutions.

Course Content:

Mathematical preliminaries and error analysis: Taylor's theorem and its relation to numerical methods, applications of sequences and series in numerical methods

Numerical methods for nonlinear equations and applications to finance: bisection and Newton-Raphson methods and their convergence, fixed point iteration with its applications and convergence, approximate solution of several financial problems in which non-linear equations are involved

Financial mathematics problems leading to system of linear equations: direct methods of solving linear systems of equations, applications to finance

Initial value problems and their applications to finance: Euler's method and higher order Taylor's series methods, Runge-Kutta methods, order of accuracy

Interpolation and extrapolation for finance: Lagrange polynomial interpolation, linear, quadratic and cubic spline interpolation, numerical differentiation and integration with applications, Richardson extrapolation

Methods of Evaluation:

End of semester exam: at least 70% of the final grade
Continuous assessment: at most 30% of the final grade

Suggested References:

1. Brandimarte, P. (2006). *Numerical methods in finance and economics : a MATLAB-based introduction*. Hoboken, N.J.: Wiley-Interscience.
2. Burden, R.L. and J Douglas Faires. (2005). *Numerical analysis*. Belmont, Ca: Thomson Brooks/Cole.
3. Cheney, E.W. and Kincaid, D. (2013). *Numerical mathematics and computing*. Boston, Ma: Brooks/Cole, Cengage Learning.

MS 2012 Introduction to Insurance (15L, 1C)

Rationale: This course discusses general concepts of insurance and insurance products.

Prerequisites: None

Intended Learning Outcomes:

By the end of the course, students should be able to

- Identify insurance as a risk mitigating method.
- Determine nature of insurance products.
- Analyze different insurance products.

Course Content:

Insurance in terms of the relationship between the insured & the insurer, purpose of insurance, different types of insurance, life insurance and general insurance, need for insurance, how insurance works, simple examples, insurance as a social security tool, role of insurance in economic development, history of insurance and life insurance.

Method/s of Evaluation:

Continuous assessment: 100%

Suggested References:

1. Dorfman, M.S. (2013). *Introduction to risk management and insurance*. Boston: Pearson.

Course Content - Department of Chemistry

CH 1006	Impact of Chemistry on Society	CH 3033	Chemistry of Bio-molecules
CH 1008	General and Physical Chemistry	CH 3054	Nutritional and Clinical Biochemistry
CH 1010	Calculations in Chemistry	CH 3071	Pharmaceutics I
CH 1011	Practical Chemistry Level I	CH 3073	Anatomy and Physiology
CH 1012	Organic Chemistry	CH 3074	Pharmacology I
CH 2002	Inorganic & Analytical Chemistry	CH 3075	Practical Pharmacy
CH 2011	Practical Chemistry Level II	CH 3076	Microbiology in Pharmacy
CH 2012	Intermediate Physical Chemistry	CH 3090	Practical Computational Chemistry
CH 2013	Introduction to Biochemistry	CH 3901	Bioanalytical Chemistry I
CH 2014	Genome structure and organization	CH 4001	Research Project
CH 3001	Topics in Analytical Chemistry I	CH 4002	Seminar and Essay
CH 3002	Practical Analytical Chemistry I	CH 4003	General Paper
CH 3003	Industrial Chemistry	CH 4004	Optional Topics
CH 3004	Laboratory Management	CH 4006	Biochemistry
CH 3005	Chemical Technology	CH 4007	Advanced Physical Chemistry
CH 3006	Computational Chemistry	CH 4008	Advanced topics in Chemistry
CH 3007	Topics in Analytical Chemistry II	CH 4070	Pharmaceutics II
CH 3008	Quality Management	CH 4071	Pharmacology II
CH 3010	Environmental Chemistry	CH 4073	Advanced Pharmaceutical Chemistry II
CH 3021	Spectroscopy	CH 4074	Quality Control, Statistics and Computer Applications
CH 3023	Coordination and Organometallic Chemistry	CH 4075	Pharmaceutical Law and Ethics
CH 3024	Pharmaceutical Chemistry	CH 4076	Pharmaceutical Management and Administration
CH 3027	Molecular Biology	CH 4077	Pharmacy Practice
CH 3029	Organic Chemistry	CH 4078	Pharmacognosy in pharmacy
CH 3030	Advanced Practical Chemistry	CH 4090	Advanced Molecular Modeling
CH 3031	Symmetry in Chemistry	CH 4901	Bioanalytical Chemistry II
CH 3032	Computer programming in Chemistry	BC 3021	Food Chemistry
BC 3022	Metabolism 1	MB 3023	Recombinant DNA Technology
BC 3023	Metabolism II	MB 3024	Topics in Molecular Cell Biology
BC 3024	Bio-Physical Chemistry	MB 3025	Recombinant DNA technology and applications
BC 3025	Protein Structure and Function	MB 3901	Molecular Cell Biology
BC 3026	Laboratory Techniques in Biochemistry and Molecular Biology	MB 3902	Animal & Plant Biotechnology
BC 3027	Enzymology	MB 3903	Nanobiotechnology
BC 3030	Practical Biochemistry and Molecular Biology	MB 4001	Genomics and Proteomics
BC 4001	Research Project	MB 4003	Molecular Evolution, Modeling & Computer Based Drug Design

BC 4002	Seminar and Essay	MB 4004	Application in Biotechnology
BC 4003	General Paper	MB 4901	Medical Biotechnology
BC 4005	Advanced Topics in Biochemistry and Molecular Biology	MB 4902	Environmental Biotechnology
BC 4006	Selected Topics in Biochemistry and Molecular Biology	MB 4903	Marine Biotechnology
MB 3003	Introduction to Genomics and Proteomics	MB 4904	Selected Topics in Biotechnology
MB 3022	Gene Expression and Regulation		

Course Code and Title:
CH 1006- Impact of Chemistry on Society
Credit Value:
2C
Rationale:
This course is designed to expose students to the applications of chemistry in selected important industries.
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- identify the types of polymers and their polymerization mechanisms.
- explain the properties of polymers based on their structures.
- explain the production process of paints, ceramics and soap.
- identify pesticides based on their structure and explain their mechanism of action.
- explain the application of electrochemical techniques used in industry.
- explain the use of petroleum products in industry.

Course Content:
Polymers: Organic polymers (polyphenols, polyvinyls), Classification and basis of classification, Polymer structure; Polymerization mechanisms, Thermal behavior, Types of interactions in polymers. Chemical industry: paints, emulsions, colloids, synthetic materials, soap and detergents, ceramics and cement, Standards and Quality assurance; Electrochemistry applications: Cells and corrosion, plating, sensors, fuel cells; Petroleum products: Formation, processing, use and environmental damage; Pesticides: Classification, mode of action of organochlorines, organophosphates, carbonates and pyrethroids, Toxicity, Environmental fate, pesticide formulations.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
Will be announced during the course.

Course Code and Title:

CH 1008- General and Physical Chemistry

Credit Value:

2C

Rationale:

This course is planned to provide the basic knowledge in atomic structure, bonding, energetics and kinetics of reactions.

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain the atomic structure using Bohr model.
- build up atoms by populating atomic orbitals according to the relevant principles.
- interpret the properties of atoms based on the Periodic Table.
- construct molecular orbital diagrams.
- explain bonding in molecules using the relevant theories.
- predict shapes of molecules using VSEPR theory.
- apply the first law and second law of thermodynamics to chemical processes.
- predict the spontaneity of chemical reactions using thermodynamic parameters.
- derive the relationships between different thermodynamic parameters.
- write rate expressions for reactions.
- calculate rate constants, orders of reactions, activation energy of reactions.
- deduce mechanisms of reactions.
- apply steady state approximations and identify intermediates.
- apply kinetic laws to consecutive reactions.
- describe the action of catalysts.

Course Content:

Atomic Structure: nature of light, photoelectric effect, wave particle duality, electromagnetic spectrum, atomic hydrogen spectrum, the Bohr model of the atom, Heisenberg uncertainty principle, quantum numbers, orbitals and their shapes, Pauli exclusion principle, Hund's rule, and Aufbau Principle. Introduction to the Periodic Table in terms of four quantum numbers, orbital shielding, calculation of the effective nuclear charge. Introduction to bonding: Types of bonds, radius ratio rules and coordination numbers, structure of ionic solids, classification of ionic solids, covalent bonding, Lewis theory, octet rule, dative bonding, resonance structures, valence bond theory, molecular orbital theory, application of MO theory to the homo nuclear diatomic molecules, molecular orbital diagrams for conjugated organic compounds (e.g. ethylene and butadiene). Chemistry of selected main group elements (e.g. B, P... etc.), Application of VSEPR method to predict shapes of organic and inorganic molecules. Energetics of Chemical processes: Heat of reactions, Thermal capacities, Kirchhoff's Equation, The first Law: Heat, Work and Internal energy, State functions and Path functions, Reversible and Irreversible processes, The second Law: spontaneous change, Entropy and irreversibility; The three laws of Thermodynamics, Universal entropy, Gibbs function, Helmholtz function. Phase Equilibria: Clausius Clapeyron equation; Kinetics and Reaction Mechanisms: Elementary reactions, rates of reactions, order and the rate constant of a reaction, steady state approximation, rate determining step, Reagents: Radical and polar reagents: Nucleophiles, Electrophiles, consecutive, reversible and reactions with equilibrium, competing reactions, chain reactions. Arrhenius equation, transition state, intermediates, energy level diagrams (S), isotope effects. Catalysis, Introduction to collision theory.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Elements of Physical Chemistry (P.W. Atkins)
(ii) Physical Chemistry (G.F. Liptrot, J.J. Thompson. G.R. Walker)
(iii) Inorganic Chemistry (Shriver and Atkins)
(iv) Inorganic Chemistry: Principles of Structure and Reactivity (J.E. Huheey) (v) Basic Inorganic Chemistry (F.A. Cotton, G. Wilkinson and P.L. Gans).

Course Code and Title:

CH 1010- Calculations in Chemistry

Credit Value:

1C

Rationale:

This course is designed to impart knowledge in the use of significant figures and propagation of errors in calculations.

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- apply the rules determining significant figures in calculations.
- calculate errors and propagation of errors.
- draw graphs using spreadsheet applications.

Course Content:

Review of basic Mathematics for Chemistry; use of significant figures and error theory; calculations based on stoichiometry; calculations based on equilibria (acid-base, buffers, solubility, etc.), probability theory, probability distribution. Redox reactions, electrochemistry, and thermodynamics; use of graphs; use of spreadsheets in chemistry.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Quantitative Chemical Analysis (Daniel C. Harris,)

(ii) Scientific Measurements and Calculations, A Monograph published by the Institute of Chemistry (S. A. Deraniyagala).

Course Code and Title:

CH 1011 -Practical Chemistry Level I

Credit Value:

2C

Rationale:

This course is designed to provide hands on experience in handling glassware, carrying out experiments and presentation of results.

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- identify cations, anions, functional groups in organic compounds using appropriate experimental techniques.
- carry out titrations involving acids and bases, redox systems.
- design an experimental procedure to solve a problem.
- record and present the results in a scientific manner.

Course content:

Practical conducted on qualitative analysis and quantitative analysis of chemical samples.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Vogel's Text book of qualitative inorganic analysis

(ii) Handouts issued in the laboratory.

Course Code and Title:

CH 1012- Organic Chemistry

Credit Value:

3C

Rationale:

This course is designed to impart knowledge in bonding, stereochemistry, conformational analysis and organic synthesis.

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- describe bonding/hybridization/molecular properties of different functional groups.
- explain the conformational stabilities of alkanes, cycloalkanes, and mono- and di-substituted cycloalkanes.
- draw Sawhorse, Newman and Fisher projection formulas of molecules.
- identify chiral centers in a molecule and assign R/S configurations.
- predict the mechanisms of nucleophilic substitution and elimination reactions of alkyl halides and alcohols.
- predict the products of or describe the reagents used in organic transformations commonly used in synthesis.

Course Content:

Overview and organic chemistry and functional groups, Structure and bonding in organic compounds (sp^3, sp^2 and sp hybridizations in alkanes, alkanes and alkanes), Electronegativity and polar covalent bonds, Intermolecular forces and molecular properties, Confirmations and conformational stabilities of alkanes (ethane, propane, butane and higher alkanes),, Sawhorse and Newman projections, Cycloalkanes (cyclopropane, cyclobutane, cyclopentane, cyclohexane and higher cycloalkanes), Stabilities of cycloalkanes, Confirmations of cycloalkanes, Conformational stabilities of mono-and di-substituted cyclohexanes, Constitutional isomerism and stereoisomerism, Chirality and optical activity, Molecules with one stereogenic center, R,S- configurations, Molecules with Fisher Projection formulas, Resolution of enantiomers, Atropisomerism Acids and bases in organic chemistry, Mechanisms and energy changes in organic reactions (energy diagrams), Alkyl halides, Ionic reactions (Sn1,Sn2,E1 and E2 reactions), Radical reactions, Structure (E/Z isomerism) stability and reactivity (electrophilic addition and oxidations) of alkenes, Structure and reactivity of alkynes, Acidity of terminal alkynes, Chemistry of alcohols and ethers and epoxides, Conjugated dienes and Diels – Alder reaction, Resonance and conjugation, Aromaticity and aromatic compounds (Hückel's Rule) Reactivity of benzene and derivatives (Electrophilic aromatic substitution), Reactions of side chains of alkyl benzenes, Reductions of aromatic compounds, Structure and reactivity (nucleophilic addition reactions, keto-enol isomerism, alpha-substitution reactions, aldol condensation reactions) of aldehydes and ketones, Conjugated enones, 1,2- vs 1,4-additions, Carboxylic acids and their derivatives, Nucleophilic acyl substitution reactions, Chemistry of aliphatic amines and aryl amines, Phenols, Aryl halides and nucleophilic aromatic substitution.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Organic Chemistry (John McMurry)

(ii) Fundamentals of Organic Chemistry (T.W.G. Solomons)

(iii) Organic Chemistry (T.W.G. Solomons and C.B. Fryhle).

Course Code and Title:

CH 2002 -Inorganic & Analytical Chemistry

Credit Value:

2C

Rationale:

This course is designed to provide in depth knowledge in analytical techniques and structure and properties of coordination compounds.

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain the theory of acid-base, complexometric and redox titrations.
- draw titration curves.
- select suitable indicators for titrations.
- explain the principles of separational methods.
- name coordination complexes using IUPAC nomenclature.
- predict the properties of coordination complexes based on their structures.
- explain the bonding and properties of transition metal complexes using the relevant theories.

Course Content:

Titrimetry: Conditional constants in acid –base, complexometric and redox titrimetry. Feasibility of titrations, selectivity based on thermodynamic and kinetic factors. Titration curves and selection of suitable indicators; Gravimetry and Precipitation Titrations: Coprecipitation, post precipitation and precipitation from homogeneous solutions. Mohr method, Volhard method and adsorption, Indicators; Separational methods: principles of solvent extraction and ion-exchange, planar chromatographic methods, paper chromatography and TLC. Gravity columns and elution chromatography; Chemistry of transition elements: Introduction to coordination complexes, structure and reactivity. Nomenclature, Bonding and properties of transition metal complexes. Theories of bonding: Valence Bond Theory, Crystal Field Theory, and Molecular Orbital Theory, Introduction to organometallic compounds of the transition metals.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Advanced inorganic chemistry (F.A. Cotton and Wilkinson)
(ii) Concise inorganic chemistry (J.D. Lee)
(iii) Inorganic chemistry (J.E. Huheey)
(iv) Fundamentals of analytical chemistry (D.A. Skoog and D.M. West)
(v) Text book of quantitative inorganic analysis (A.I. Vogel)
(vi) Determination of pH: theory and practice (R.G. Bates)
(vii) Analytical chemistry (J.D. Dick)

(viii) Chemical separations and measurements: theory and practice (D.G. Peters, J.M. Hayes and G.M. Hieftje) (ix) Inorganic Chemistry (D.F. Shriver, P.W. Atkins and C.H. Langford).

Course Code and Title:
CH 2011- Practical Chemistry Level II
Credit Value:
2C
Rationale:
This course is designed to train students in designing and carrying out experiments, taking measurements using instruments, interpretation, analysis and presentation of results.
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- identify functional groups in organic compounds using appropriate experimental techniques.
- predict the structures of organic compounds using spectroscopic methods.
- synthesize and purify organic compounds.
- carry out titrations involving acids and bases, redox systems and complexometry.
- apply spectroscopic techniques to quantify compounds.
- apply separational techniques to purify and quantify compounds.
- use physical methods to study reactions.
- determine thermodynamic and kinetic parameters of reactions.
- design an experimental procedure to solve a problem.
- record and present the results in a scientific manner

Course content:
Practical conducted in the areas of Organic Chemistry, Inorganic Chemistry and Physical Chemistry.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Vogel's Text book of qualitative inorganic analysis
(ii) Vogel's Text book of quantitative chemical analysis
(iii) Handouts issued in the laboratory.

Course Code and Title;

CH 2012- Intermediate Physical Chemistry

Credit Value:

3C

Rationale:

This course is designed to give the theoretical knowledge of quantum chemistry, spectroscopy, phase equilibria and electrochemistry required for further learning.

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- describe experiments that show that Newton's laws are not applicable to small particles.
- carry out calculations involving operators and functions.
- describe postulates in quantum mechanics.
- apply quantum mechanics to a particle in 1-D, 2-D and 3-D boxes.
- calculate expectation values and probabilities.
- describe H-atom wave functions.
- apply the principles of thermodynamics to explain surface phenomena.
- carry out calculations involving adsorption isotherms.
- predict the mechanisms of surface catalyzed reactions.
- explain the interaction of radiation with matter.
- explain the process of absorption and emission of radiation by matter.
- carry out calculations involving Beer-Lambert law.
- explain the rotational motion, rotational energy levels and rotational spectra.
- explain the vibrational motion, vibrational energy levels and vibrational spectra.
- use NMR spectroscopy and mass spectrometry in structure elucidation.
- explain the conductivity in terms of ionic motion.
- use conductivity measurements to determine acid dissociation constants, end points of titrations etc.
- construct electrochemical cells and apply Nernst equation.
- predict activity of chemical species in solution using Debye-Hückel theory.
- apply phase rule to multiphase multicomponent systems.
- construct and interpret phase diagrams.

Course Content:

Quantum Chemistry: Inadequacy of Newton's laws; Operators, Eigen functions and Eigen values, Hermitian operators, Heisenberg Uncertainty Principle, Postulates of quantum mechanics, Schrödinger equation, Born interpretation of the wave function, normalization, orthogonality, particle in a 1-D, 2-D and 3-D boxes, degeneracy. Hydrogen and hydrogen like atoms, spin. Surface Chemistry: Interfaces, surface films on liquids, adsorption on solid surfaces, Langmuir and BET isotherms, colloids and membranes. Physical Basis of

Spectroscopy: wave and particle nature of matter. Interaction of radiation with matter, energy levels. Absorption and emission of radiation. The basic spectroscopic experiment, Spectrum fine structure, population distribution (Boltzmann distribution), selection rules (electronic, rotational, vibrational, NMR), Time scales (uncertainty principle), Basic instrumentation for absorption experiment, Beer-Lambert law, Electronic spectroscopy of atoms, Electronic spectroscopy (UV/VIS) of molecules, Principles of NMR spectroscopy. Brief introduction to NMR spectroscopy of 1P, 19F; Molecular Spectroscopy: Vibrations of diatomic molecules, simple harmonic oscillator, anharmonic oscillator, effect of isotopic substitution, dissociation energy. Rotational spectroscopy: rigid rotor model, intensities of spectral lines, calculation of moment of inertia, internuclear distance for a rigid diatomic molecule, Vibration-rotation spectroscopy, P, Q and R bands, Rotational spectra of non-rigid diatomic molecules; Applications of UV, IR, NMR and Mass spectrometry in Organic Structure Elucidation. Electrochemistry: Electrolytes and non-electrolytes, conductance, conductivity, molar conductivity, Kohlraush's law and Ostwald's dilution law, limiting ionic conductivity, chain mechanism of H^+ migration, Debye-Hückel theory of activity, Debye-Hückel limiting law, Electrode and cell reactions, Nernst equation. Definitions of phase, components and degrees of freedom, phase rule, One component, two component and multi component systems. Phase diagrams and phase transitions. Thermodynamics of phase transitions.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Elements of Physical Chemistry (P.W. Atkins)

(ii) Physical Chemistry (G.F. Liptrot, J.J. Thompson. G.R. Walker)

(iii) Physical Chemistry (P.W. Atkins).

Course Code and Title:
CH 2013- Introduction to Biochemistry
Credit Value:
2C
Rationale:
This course is designed to impart knowledge in the application of thermodynamic principles in biological systems, structure, properties and functions of important biomolecules.
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- describe types of molecular/ionic interactions important in biochemical systems.
- describe energy transactions in biological systems.
- predict the feasibility of metabolic processes.
- describe types of reactions in biological systems.
- explain the role of the cell membrane in cellular functions.
- explain structure-function relationship of biomolecules.
- describe the use of properties of biomolecules in their identification.

Course Content:
Chemistry and life; cells; aqueous solutions; review of acid-base equilibria and buffers; review of thermodynamic principles; weak interactions in biochemistry – H-bonds, polar interactions, dispersion forces, hydrophobic effect. Bioenergetics: Energy relationship between catabolic and anabolic pathways, free energy of biochemical reactions, Energy coupling in ion transport and biochemical reactions, Phosphoryl group transfer and ATP as currency of free energy, high energy compounds, Oxidation – Reduction reactions in biological systems, Amino acids-structures, side chains, three-and one-letter abbreviations, zwitterions, pI, peptide bonds. Peptides and proteins – function: purification techniques; primary, secondary, tertiary, and quaternary structure. Secondary structure – alpha helices, beta sheets, random coils, Tertiary and quaternary structure- fibrous and globular proteins, protein folding and denaturation. Carbohydrates- function; classification; stereochemistry; structures of aldoses. Fischer and Haworth projections; ketoses; anomers and epimers; derivatives of monosaccharides; glycoside bonds; disaccharides; polysaccharides (starch, cellulose, chitin) Nucleotides and nucleic acids – purine and pyrimidine bases, nucleotides, formation of nucleic acids, base-pairing and double-stranded DNA, stability of DNA, Lipids – triglycerides, waxes, steroids, phospholipids. Membranes – structure, membrane proteins, membrane transport (mechanisms and energetics).
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Biochemistry (C. K. Mathews & K. F. van Holde)
(ii) Biochemistry (D. Voet & J. G. Voet).

Course Code and Title:
CH 2014 - Genome structure and organization
Credit value:
1C
Rationale: This course aims to provide a basic introduction to genome organization of different organisms and how they are organized to achieve structural, functional and biological complexity, and chemical and physical methods that are available to study the structural organization of genomes.
Pre-requisites:
BT 2015 / BT 2016
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- identify different structural DNA elements and their distribution in prokaryotic and eukaryotic genomes.
- differentiate viruses according to their genome organizations.
- compare different structural DNA elements and their distribution in prokaryotic and eukaryotic genomes.
- recognize the chemical and physical methods used in analysis of the complexity of genomes.
- discuss the significance of non-coding regions in the genome.
- identify different regions of chromosomes, type of chromosomes, different level of chromosome organization, chromosome modifications.
- identify different types of extrachromosomal genomes.
- discuss the various fields of genomics and the importance in understanding life.

Course Content:
Nucleic acids, DNA secondary structure, higher order (tertiary) structure of DNA and RNA. Structure and organization of prokaryotic genomes (e.g. *E. coli*, *Mycobacterium tuberculosis* etc.), Transcriptional regulators of prokaryotes genes. Transposable genetic elements in prokaryotic genomes. Evolution of bacterial operons. Islands and segments of pathogenicity and resistance. Structure and organization of viral genomes (dsDNA , ssDNA, dsRNA, ssRNA negative strand, ssRNA positive strand, Retroid, Satellites etc.,). Genome complexity in terms of C-value paradox, Denaturation and Renaturation kinetics - Cot Values, genome size and biological complexity (minimum genome sizes, ratio between coding to non coding sequences etc), repetitive and non-repetitive DNA; Chromosome: Structure of a typical circular and linear chromosomes, molecular nature and functioning of centromeres and teleomeres, telomeric and subtelomeric regions in chromosomes, Giant chromosome, Polytene chromosome, karyotypes. Chromatin Organization: Euchromatin, Heterochromatin, Nucleosome as a subunit of chromatin, organization of hisotone octamer. Structure and organization of eukaryotic genomes (e.g. *Saccharomyces cerevisiae*, *Candida albicans*, filamentous fungi, *Drosophila melanogaster*, *Caenorhabditis elegans*, *Arabidopsis thaliana*,

Homo sapiens etc). Repetitive and transposable elements and their effect on genome. Subcellular genomes, extrachromosomal genomes, Organelle genome (mitochondrial, Chloroplast etc).

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Genes VIII (B. Lewin)

(ii) Molecular Cell Biology (Harvey Lodish).

Course Code and Title:
CH 3001- Topics in Analytical Chemistry I
Credit Value:
2C
Rationale:
This course is designed to provide advanced knowledge in separational methods and electroanalytical techniques.
Pre-requisites:
First year and second year chemistry core courses
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- explain the processes involved in chemical separations and electro analytical techniques.
- carry out calculations involving the principles of electro analytical chemistry.
- apply the underlying principles in qualitative and quantitative analysis.
- use standard equipment in analytical chemistry.

Course Content:
Separational Methods: Ion Exchange: Kinetics, Donnan Equilibrium, Affinity; Solvent Extraction: Distribution coefficient and distribution ratio, Extraction strategies, Chelating agents for the extraction, Masking; Chromatography: Elution chromatography, Selection of the mobile and stationary phases, Separation mechanisms, Sorption Isotherms, Retention time, Distribution coefficient, Capacity Factor, Selectivity, Efficiency, Resolution, Temperature (solvent strength) programming, Band broadening process, van deemter Equation for GC, H vs u curves for GC and LC, Chromatographic methods for qualitative and quantitative analysis, Instrumentation, GC and HPLC trouble shooting, Size-exclusion chromatography, Supercritical fluids and its applications, Supercritical fluid extraction and Supercritical fluid chromatography. Electroanalytical Techniques: Electrophoresis, Applications Electro analytical methods; Coulometry, coulometric titration, electrogravimetry, polarography: dc-, ac-, pulse, differential pulse, stripping voltammetry, amperometry, potentiometry, ion and molecular selective electrodes, carbon paste electrodes potentiometric titration, conductometry, conductometric titration.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Text book of quantitative inorganic analysis (A.I. Vogel)
(ii) Determination of pH: theory and practice (R.G. Bates)
(iii) Analytical chemistry (J.D. Dick) (iv) Chemical separations and measurements: theory and practice (D.G. Peters, J.M. Hayes and G.M. Hieftje).

Course Code and Title:

CH 3002- Practical Analytical Chemistry I

Credit Value:

1C

Rationale:

This course is designed to provide advanced training in experimentation, use of instruments, data collection, analysis and presentation.

Pre-requisites:

Level I and Level II chemistry core courses

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- apply advanced instrumental techniques for chemical analysis.
- investigate and solve research based problems using scientific methods.
- effectively communicate any findings and defend the work in a professional manner.

Course Content:

Practical conducted in the relevant areas to develop research techniques and advanced analytical techniques.

Method/s of Evaluation:

End of the semester examination

Recommended Readings:

Handouts issued in the laboratory.

Course Code and Title:

CH 3003 - Industrial Chemistry

Credit Value:

2C

Rationale:

This course is designed to provide knowledge in the use of chemical principles in industry.

Pre-requisites:

CH 1006

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- interpret the TGA graph and determine the component constituents.
- explain the cement manufacture process.
- analyze the given situation and identify the best type of cement for a given set of conditions based on the cement constituent properties.
- differentiate between homogeneous and heterogenous catalysts.
- explain the application of catalysts in industry.
- identify types of polymerization reactions and mechanisms.
- interpret polymer properties.
- identify structure – end use relationship.
- devise suitable polymers for a particular end use.
- identify POPs based on their structure.
- explain the distribution of POPs in the environments on the basis of their physico-chemical properties.
- explain the mechanism of action of POPs.

Course Content:

Introduction to Thermal analysis, Thermogravimetric analysis (TGA) – Introduction, instrumentation, interpretation of thermogram, Industrial application of TGA Manufacture of Portland cement, properties of different constituents of cement on setting and hardening, types of cement, weathering of cement, Catalytic terminology, classification of catalyst, differentiate between homogenous and heterogeneous catalysis, application of homogenous and heterogeneous catalysis in industry, Introduction to polymer chemistry, vinyl polymers; mechanism of addition polymerization and introduction of terms and concepts, polymerization of diene monomers, condensation polymerization; polyesters, polyamides, polycarbonates, ladder polymers, formaldehyde resins, ring opening polymerization; polycaprolactam, epoxy resins, poly propylene oxide, cationic polymerization, anionic polymerization, coordination polymerization, bonding and polymer structure, chemical bond and intermolecular forces, configuration, tacticity, crystalline and amorphous structure of polymers, polymer properties, glass transition temperature and crystalline melting point, factors affecting T_g and $T_{m,}$ copolymerization and polymer modification, molecular weight, polymer applications, Persistent Organic Pollutants (POPs), namely PCDDs / PCDFs; PCBs, PAHs, PBDEs, Organochlorine pesticides: What they are, why they are important, how their physicochemical properties (K_{ow}, K_{OA}, W_s, K_{OC}, VP, H, Environmental persistence) that govern their environmental fate and behavior, mechanism of action, toxic effects. Source inventories. Environment budget.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Handbook of industrial catalysts (Lawrie Lloyd)

(ii) Industrial Catalysis - A Practical Approach (Jens Hagen)

(iii) Polymer Science and Technology (Robert O Ebewele).

Course Code and Title:

CH 3004- Laboratory Management

Credit Value:

1C

Rationale:

This course is designed to provide knowledge on good laboratory practices and the process of documentation.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- demonstrate the basic principles, theories, and regulations related to the laboratory management.
- demonstrate the ability to use appropriate tools to solve issues related to safety and efficiency of laboratory.

Course Content:

Common mistakes in laboratories: The Storytelling Syndrome, The Teacher's Pet Syndrome. Standard operating procedures (SOP): Anatomy of SOP, Development of SOPs, Sample SOPs. Efficiency and safety: Self-contained paperwork system, Task-oriented workload, Support systems, Work-hour matching, safety/housekeeping awareness. Capabilities and training: Passenger identification and removal process, Training Supervision: Total-immersion supervision, Accelerated problem-solution loop. Laboratory geography and technology of QC: layouts of QA/QC and R&D the laboratories, Physical facilities, Quality Assurance for the Laboratory: Equipment calibration and maintenance, Standards, Reagents, Volumetric solutions, Analytical methodology, Documentation, Control schedules, Retention of samples, Reporting and treatment of data, Statistical quality control, Quality control charts. Flow charts for laboratories: Analytical or testing operations flowchart, Laboratory safety standard: Internal safety program, introduction to OSHA Laboratory Standard, Performance Reviews, Laboratory environment, Job satisfaction.

https://www.osha.gov/SLTC/laboratories/standards.html

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Successful Management of the Analytical Laboratory (I. Milner)

(ii) Occupational Safety and Health Administration (https://www.osha.gov/).

Course Code and Title:
CH 3005- Chemical Technology
Credit Value:
2C
Rationale:
This course is designed to provide an advanced knowledge on processes involved in chemical industries.
Pre-requisites:
CH 3003
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- interpret the E-pH diagrams and identify corrosion control methods using the diagrams.
- analyze the mixed potential theory diagrams and predict the effects of pH, cathodic reaction, reducible species, solution velocity, inhibitors.
- explain types of corrosion and types of corrosion prevention.
- explain why additives are needed for the stability of polymers.
- differentiate between polymerization methods and their applications.
- select reactors for different applications.

Course Content:
Introduction to corrosion, E-pH(Pourbaix) diagram of metals – Fe, Au, Cu, Zn, Al; Strategies for corrosion control from E-pH diagrams; Limitations of using E-pH diagrams on corrosion control. Kinetics of corrosion; Tafel plots of different metals; Polarization – activation, concentration, ohmic polarization, Application of mixed potential theory diagrams – effect of pH, increasing rates of the cathodic reaction, increasing concentration of the reducible species, increasing solution velocity, effect of inhibitors on corrosion of active metals and active-passive metals. Types of corrosion: Corrosion due to differential aeration, crevice, galvanic, pitting, stress cracking, Corrosion prevention by cathodic protection, anodic protection, inhibitors, sacrificial anode, protective coating. Polymer stability; Polymer additives: plasticizers, antioxidants, thermal and uv stabilizers, flame retardants; Polymerization methods: bulk, solution, suspension and emulsion polymerization; Polymerization reactors: batch and continuous stirred reactors; Unit operations: extrusion, injection moulding, blow moulding; Applications. Introduction, Recent history of chemical industries, Introduction to chemical technology and chemical industries, Back ground and technical aspects, The economy of scale $M = M_0(Q/Q_0)^n$, $C = C_0(Q/Q_0)^n$, Chemical processing, unit operations, unit process, thermal and mechanical unit operations, Type of reactors, batch, semi-batch, CSTR, multistage CSTR, tubular flow ,Conversion and yield, Academic yield, industrial yield, % conversion, Catalysts Homogeneous, heterogeneous and bio-catalysis, Production and characterization of catalysts, Deactivation of catalysts, Environmental aspects of chemical technology, pollution, water treatment and waste water management, Green chemistry, Examples of industrial processes.

Method/s of Evaluation:

End of semester examination

Recommended readings:

(i) Corrosion: Understanding the basics (J. R. Davis)

(ii) Fundamentals of electrochemical corrosion, (E.E. Stansbury, R.A. Buchanan)

(iii) Polymer Science and Technology (Robert O Ebewele).

Course Code and Title:

CH 3006- Computational Chemistry

Credit Value:

2C

Rationale:

This course is designed to provide an advanced knowledge in quantum mechanics and molecular dynamics required for computation of molecular properties.

Pre-requisites:

First year and second year chemistry core courses

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- predict properties of non-interacting entities using quantum mechanics.
- apply approximate methods to predict properties of complex systems.
- apply quantum mechanics to multi-electron systems.
- apply classical mechanical methods to predict properties of multi-particle systems with many degrees of freedom.

Course Content:

Quantum Mechanics & Computational methods: Exactly solvable problems; free particle, harmonic oscillator, 2D and 3D rotational motion, Hydrogen atoms, atomic units, Approximate methods, Many electron systems, Born-Oppenheimer approximation, Pauli exclusion principle, spin and spatial orbitals, Variation and perturbation methods, Huckel molecular orbital theory, Hartree products, Slater determinants, configuration interaction, Hartree-Fock approximation, Coulomb and exchange integrals, Hartree-Fock equations, Orbital energies, Commutation relations, Koopman theorem, Brillouin's theorem, Introduction of a basis, Roothaan equations, orthogonalization of the basis, The self-consistency procedure, Semi-empirical and ab-initio calculations. Molecular Properties & Molecular Dynamics**:** The electric dipole, vector addition of dipole moments, induced dipole moments, Charge-charge interactions, charge-dipole interactions, dipole-dipole interactions, dipole-induced dipole interactions, induced dipole-induced dipole interactions, total attractive interactions, effect of rotation, Axilrod-Teller formula, Mie potential, Lennard-Jones potential, hydrogen bonding interactions, multipoles; Minimum energy structure of a molecule, methods to obtain minimum energy; Molecular dynamics simulation, modeling liquids and solvation.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Quantum chemistry (D.A. McQuarrie)

(ii) Molecular modeling: principles and applications (A.R. Leach)

(iii) Quantum Chemistry (I. N. Levine).

Course Code and Title

CH 3007 – Topics in Analytical Chemistry II

Credit Value:

1C

Rationale:

This course is designed to provide in depth knowledge in analytical methods and method validation.

Pre-requisites:

CH 2008, CH 3001 recommended

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- demonstrate the principles and theories related to analytical chemistry.
- carry out calculations using theoretical knowledge.
- demonstrate the ability to use appropriate tools and techniques to develop new analytical methods.
- explain recent developments in analytical chemistry.

Course Content:

Tools in Analytical Chemistry: Systematic and random errors in analytical chemistry, Sample standard deviation, Precision, Propagation of errors, Confidence limits, Expression of the results of analysis. Rejection criteria (Q-test). Statistical Aids to Hypothesis Testing: Qualitative and quantitative tests method validation. Limit of detection and limit of quantification: Understand the basics of LOD and LOQ determination for a given test method. Metal ligand complexes in Analytical Chemistry: Metal-ligand complexes, Parasitic reactions and Conditional formation constants, Estimate the feasibility of a titration, Indicator selection process, Formal potential, Eh and pEMasking (Sequestration): Selection of masking agents for titrimetry, Precipitation, Colour development, Effect of sequestration on redox reactions, Advance Instrumental methods: Discuss recent developments in analytical chemistry.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Fundamentals of Analytical Chemistry (D. Skoog and D. West)

(ii) Principles of Instrumental Analysis (D. A. Skoog, F. J Holler, S. R. Crouch)

(iii) Principles and Practices of Method Validation (A Fajgelj, A Ambrus).

Course Code and Title:
CH 3008 - Quality Management
Credit Value:
1C
Rationale:
This course is designed to provide knowledge in quality assurance methods and standards in analytical chemistry.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- demonstrate and understand the basics principles, theories, and regulations related to quality management.
- demonstrate the ability to use appropriate tools to solve issues related to quality in laboratories.

Course Content:
Glossary of Analytical Chemistry Terms: Terms Related to Quality Management, General, Statistics, Measurement, Error and Uncertainty, Important Organizations and their web pages.
Background on the accreditation of testing and calibration laboratories: ISO/IEC 17025 and ISO 15189, Significance of accreditation and certification for laboratories, Good Laboratory Practice (GPL), An overview to the laboratory accreditation process. Quality Manual: Quality manual contents for ISO/IEC 17025 and main requirements, Use examples to demonstrate how these requirements can be met. Sampling: Type of sampling, Sampling planning, Subsampling, Examples for sampling plans. Calibration techniques and methods for QC and QA laboratories: Basics in calibrations, International Standards, Preparation of the standard samples, Linear and 2nd order calibration functions, Linearity and outlier tests, International standard, LOD and LOQ. Basic Statistics for quality management and Charts: Statistical methods for quality management, CUSUM and control charts (Shewhart charts). Reference Materials and Certified Reference Materials: An overview of the role of reference materials in quality assurance in analytical laboratories. Inter laboratory Tests: Types of Inter Laboratory Tests, Objectives of each type, Requirements, and selection of participating laboratories.
Method/s of Evaluation:
End of the semester examination
Recommended Readings:
(i) ISO/IEC 17025:2005 - General requirements for the competence of testing and calibration laboratories (http://www.iso.org)
(ii) Quality Assurance and Quality Control in the Analytical Chemical Laboratory: A Practical Approach (P. Konieczka, J. Namiesnik).

Course Code and Title:
CH 3010 Environmental Chemistry
Credit Value:
2C
Rationale:
This course is designed to provide knowledge on Method/s of Evaluation of the quality of air, water and soil and treatment methods.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- explain the environmental problems related to air, water and soil.
- illustrate the principles and procedures to sample and analyze airborne pollutants.
- analyze the health effects of airborne pollutants and predict the consequences using a model.
- distinguish the suitability of water for drinking and irrigation purposes.
- illustrate the principles of wastewater treatment.
- recognize the importance of chemical speciation.
- interpret a Poubaix diagram.
- correlate the soil structure to its properties and transport of water through soil.

Course Content:
Chemistry of Air: Indoor air quality, Understanding the problems associated with indoor air, Indoor pollutant sources, Health impacts due to inhalation of indoor air, Handling indoor air pollution problems, Indoor air quality modelling, Continuous Fluid Stirred Tank Reactor model, Basis for the model and its applications, Method/s of Evaluation of the exposure and health effects, Real time vs continuous air sampling, Active and passive sampling, Sampling of particles and analysis methods, Sampling of gaseous pollutants and semi-volatiles, Sampling and analysis of CO, SO_x and NO_x. Aquatic Chemistry: Nature of water, Calculations involved in aquatic chemistry – concentration units, Sampling of water. Water purification, Water quality parameters. Suitability of potable waters. Suitability of water for irrigation, Water treatment: Municipal wastewater treatment, Wastewater disinfection, Use and disposal of biosolids, Chemical speciation of elements, Redox Chemistry of water: Electron activity, pE and Eh measurements, pe-pH and Eh-pH diagrams, Pourbaix diagram for water and iron, Corrosion diagram for the Fe-H_2O-O_2 system. Chemistry of Soil: Soil composition, structure of soil, its properties, Transport of water through soil, Ion exchange properties of soil.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) ASTM and Sri Lanka Standards
(ii) Methods for chemical analysis of fresh water (H.L. Golterman)

(iii) The hydrogeochemical Atlas of Sri Lanka (C.B. Dissanayake, S.V.R. Weerasooriya)
(iv) Environmental Chemistry (R.D. Raiswell, R.D. P. Brimblecombe and P.S. Liss)
(v) Text book of quantitative inorganic analysis (A.I. Vogel)
(vi) Analytical chemistry (J.D. Dick)
(vii) Chemical separations and measurements: theory and practice (D.G. Peters, J.M. Hayes and G.M. Hieftje).

Course Code and Title:
CH 3021- Spectroscopy
Credit Value:
3C
Rationale:
This course is designed to provide advanced knowledge on theoretical aspects and application of spectroscopic techniques in structure elucidation.
Pre-requisites:
First year and second year core courses in chemistry
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- explain principles underlying the NMR phenomenon in relation to the observed spectra of organic and inorganic compounds.
- elucidate the structures of organic and inorganic molecules using NMR and MS spectroscopic data.
- apply theoretical approach to explain molecular structure and bonding.
- predict rotation, vibration and Raman spectra of molecular systems.
- explain the nature of ESR, NQR and Mossbauer spectroscopy applicable for inorganic molecules and complexes and analyze structural information obtained by these spectroscopic methods.
- explain the principles of atomic absorption spectroscopy.
- apply atomic absorption spectroscopy to identify and quantify metal ions in a compound.

Course Content:
Introduction to NMR and MS spectroscopy: NMR Spectroscopy: Magnetic nuclei, CW and Pulsed FT NMR, Signal to noise ratio, Effects of high field, Chemical shift and factors affecting chemical shift Coupling constants and mechanism of coupling, Chemical equivalence and magnetic equivalence, Homotopic, enantiotopic and diastereotopic nuclei, NOE effect, Protons on hetero atoms, Second order spectra, Shift reagents and chiral resolving agents, ^{13}C NMR spectroscopy, The APT and DEPT experiments, Introduction to 2D NMR, COSY, HETCOR and HMBC spectra, Applications in structure elucidation of organic molecules. Mass Spectrometry: EI and fragmentation mechanisms, CI, FAB, MALDI, Electrospray ionization, MS/MS in structure elucidation of organic molecules. Rotation and vibration Spectroscopy: Microwave spectroscopy of linear polyatomic molecules; Introduction to microwave spectra of symmetric top, spherical top, asymmetric top and molecules. UV- Visible spectra of diatomic and polyatomic molecules; Rotation-vibration spectroscopy of linear triatomic / diatomic molecules; relations with experimental spectra; Raman Spectroscopy: Raman Effect on rotation and vibration spectra, Experimental evidence of Raman Effect. Inorganic spectroscopic methods: Inorganic NMR spectroscopy for compounds containing spin ½ nuclei of ^{19}F, ^{31}P and NMR spectroscopy with spin >1/2 such as ^{14}N, ^{10}B, ^{11}B and NMR signals

obtaining for ^{1}H proton coupled to metal centers such as Rh, and quadrupole nucleuses such as Co. Electron Spin Resonance Spectroscopy (ESR);Electron-electron coupling, Hyperfine couplings and g-factors, Coupling of one electron with several spin active nuclei and ESR spectral pattern of many electron systems (transition metal complexes).Nuclear quadrupole resonance (NQR) and structural information from NQR. Mossbauer spectroscopy for Fe and Sn complexes. Atomic Spectroscopy: Atomic Absorption Spectrometry: Instrumentation: Radiation sources (hollow cathode lamp, electrodeless discharge lamps), Atomization techniques (flame, electrothermal, cold-vapor, hydride), Monochromators, Photomultiplier tube, Spectrophotometers (single beam, double beam) Interferences: Spectral Interferences, Chemical Interferences. Analytical Techniques: Standard calibration curve, Standard addition method. Atomic Emission Spectrometry: Instrumentation: Radiation sources (flame, plasma) Interferences: Spectral Interferences, Chemical Interferences.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Introduction to Spectroscopy: A Guide to Students of Organic Chemistry (D.L. Pavia, G.M. Lampman and G.S. Kriz)
(ii) Spectrometric Identification of Organic Compounds (R.M. Silverstein and F.X. Webster)
(iii) NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry (E. Horwood)
(iv) Physical Methods for Chemists (R.S. Drago)
(v) Spectroscopy (D.R. Browning)
(vi) Principles of Instrumental Analysis (D.A. Skoog, F.J. Holler, T.A. Nieman), Quantitative Chemical Analysis (Daniel C. Harris).

Course Code and Title:

CH 3023 – Coordination and Organometallic Chemistry

Credit Value:

3C

Rationale:

This course is designed to provide advanced knowledge in structure, reactivity and reaction mechanisms of organometallic and coordination compounds.

Pre-requisites:

First year and second year chemistry core course units

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- compare and contrast transition-metal coordination complexes and organometallic complexes.
- explain the nature of bonding that occurs between metal and important π-bonding ligands in stabilizing metal complexes.
- identify the basic reactivity patterns that occur in transition metal organometallic complexes and ligand activation.
- explain the involvement of transition metal organometallic complexes as catalysts in very important industrially useful reactions and to realize their mechanisms.
- predict the mechanism involve for a given catalyst upon given reactants and products.
- explain the inorganic reaction mechanisms and classification of inorganic reactions as substitution, electron transfer and activation of ligands.
- recognize and apply the kinetics laws of substitution reactions that occur at square planar, tetrahedral and octahedral metal complexes.
- identify and explain inner sphere and outer sphere mechanisms involved in complexes.
- explain the stability of transition metal complexes.
- interpret the spectroscopic and magnetic properties of transition metal complexes.

Course Content:

Advanced Coordination Chemistry: Crystal Field Theory and Chelate compounds, Octahedral Site Stabilization Energy, Electronic spectra of transition metal complexes: Russell-Saunders Coupling, Orgel diagrams, Tanabe-Sugano diagrams. Magnetic properties: classification of the types of magnetic behavior: Crystal Field interpretation of the origin of paramagnetism. Organometallic Chemistry and Catalysis: Introduction to Organometallic Chemistry, Metal-ligand bonding, Introduction to important π-bonding ligands, Dewar-Chatt-Duncanson model, metal-ligand reactivity patterns, reactivity of metal-bound ligands, Homogeneous catalysis, Chemistry of ferrocene, Synthesis, structure and bonding. Inorganic Reaction Mechanisms: Ligand substitution reactions, classification of substitution reaction mechanism, Substitution reactions of octahedral and square planar and tetrahedral metal complexes, stereochemical changes, isomerization, fluxional behavior, and electron transfer reactions.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Inorganic and Organometallic Reaction Mechanisms (J.D. Atwood)

(ii) Inorganic reaction Mechanisms (M.L. Tobe)

(iii) Mechanisms of Inorganic Reactions (I. Basolo and R.G. Pearson)

(iv) Cluster Molecules of p-Block Elements (C.E. Housecroft) (v)

(v) Multiple Bonds Between Metal Atoms (F.A. Cotton and R.A. Walton)

(vi) Physical Methods for Chemists (R.S. Drago)

(vii) Spectroscopy (D.R. Browning) (vi) The Organometallic Chemistry of the Transition Metals (Robert H. Crabtree)

(viii) Concise Inorganic Chemistry (J.D. Lee)

(ix) Advanced Inorganic Chemistry (F.A. Cotton and R. Wilkinson).

Course Code and Title
CH 3024 - Pharmaceutical Chemistry
Credit Value:
2C
Rationale:
This course is designed to provide an in depth knowledge on structure-activity relationship of drugs and their action.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- develop critical thinking skills towards what the body does to the drugs and what the drug does to the body.
- recognize representative anticonvulsant, local anesthetic, anti-inflammatory, diuretics, anti-diabetic, anti-bacterial anti-fungal, anticancer, and antiviral drugs and their respective mechanisms of action.
- explain structure-activity relationships of some selected drugs.
- propose routes to some synthetic drugs.
- explain beta-lactam drug resistance mechanisms.

Course Content:
Pharmaceutical, Pharmacokinetic, Pharmacodynamic aspect of a drug molecule: Biopharmaceutical properties of drug substances (Gastrointestinal physiology, Mechanisms of drug absorption, Drug dissolution versus drug absorption), Receptors and drug action (Affinity-the role of chemical bonding, Dose-response relationships, Receptors and biological response), Drug metabolism (Drug biotransformation pathways and Drug conjugation pathways). Drugs related to the Central Nervous System: Volatile Anesthetics, Anticonvulsants (Seizures, Anti-convulsant with ureide structure and synthesis, Benzodiazepines, Local Anesthetics (Electrophysiology of nerve membrane and mechanism of action). Cholesterol lowering drugs and Adrenocorticoids: Cholesterol biosynthesis (highlight the connection to anti-fungal agents) and statins, Development of adrenocorticoid drugs (Anti-inflammatory steroids), Introduction to Adrenocorticoid antagonists which will be expanded under diuretics). Diuretics: Osmotic diuretics, Carbonic anhydrase inhibitors, Thiazide diuretics, Loop diuretics, Potassium sparing diuretics. Drugs affecting sugar metabolism: Hormonal inter-relationships, Insulin, Oral anti-diabetic agents (Biguanides, sulfonylureas). Anti-microbial agents: General principles and important definitions, Anti-bacterial compounds (Sulfonamides, beta-lactam antibiotics, Aminoglycosides, Tetracyclines), Anti-mycobacterial agents, Anti-fungal agents (Polyenes, Azoles and allylamines), Antiseptics and Disinfectants. Anti-cancer and Anti-viral drugs: Anti-neoplastic drugs (Anti-metabolites, Alkylating agents, DNA-intercalating agents, Anti-mitotic agents), Anti-viral agents, Approach to Anti-Aids agents. Biopharmaceutical properties of drug

substances (Gastrointestinal physiology, Mechanisms of drug absorption, Drug dissolution versus drug absorption), Receptors and drug action (Affinity-the role of chemical bonding, Dose-response relationships, Receptors and biological response), Drug metabolism (Drug biotransformation pathways and Drug conjugation pathways) Cholesterol biosynthesis (highlight the connection to anti-fungal agents) and statins, Development of adrenocorticoid drugs (Anti-inflammatory steroids), Introduction to Adrenocorticoid antagonists which will be expanded under diuretics).

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Principles of Medicinal Chemistry (William O. Foye, Thomas L. Lemke, David A. Williams)

(ii) Introduction to Medicinal Chemistry (Patrick Graham)

(iii) Medicinal Chemistry (Thomas Nogrady, Donald F. Weaver).

Course Code and Title:
CH 3027 – Molecular Biology
Credit Value:
2C
Rationale:
This course is designed to provide an in-depth knowledge on gene structure, DNA technology and its applications.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- identify operon, and list its parts.
- explain how a regulator gene controls transcription of an operon.
- explain the regulation of the *trp* and *lac* operons.
- identify different levels at which gene expression in eukaryotes may be regulated.
- explain how DNA modifications, Chromatin remodeling etc., used in activation and repression of gene expression.
- describe the different tools used in rDNA technology.
- compare the different strategies used for gene cloning.
- design a PCR assay.
- explain how DNA is characterized and analyzed.
- describe the different applications of rDNA technology.

Course Content:
Gene structure; Prokaryotic and eukaryotic gene transcription; Transcription factors, activators and repressors, Mechanism of activation and repression; DNA modifications, Chromatin remodeling. Tools of Molecular Biology; Microorganisms, enzymes & vectors. Cloning; Techniques of cloning; Cutting & joining DNA molecules using enzymes, gene transferring methodologies, Gel Electrophoresis, Blotting techniques (Southern and Northern) DNA Labelling techniques, Nucleic acid Hybridization; Strategies for gene isolation, Construction and screening of genomic & cDNA libraries, DNA sequencing and analysis, Chromosome walking, PCR. Applications of recombinant DNA technology in Medicine, Agriculture and Industry, Recent advances in rDNA technology.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Genes VIII (B. Lewin)
(ii) Recombinant DNA (Watson *et al*)
(iii) Understanding DNA & gene cloning (K. Drlica).

Course Code and Title:

CH 3029 – Organic Chemistry

Credit Value:

3C

Rationale:

This course is designed to provide an advanced knowledge on organic synthesis, reaction mechanisms and structure-reactivity relationship.

Pre-requisites:

CH 1012

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- describe the mechanisms of the major classes of organic reactions.
- predict the mechanisms of simple reactions previously unseen.
- describe and predict the reactivities of organic compounds using the principles of physical organic chemistry.
- predict the products of or describe the reagents used in organic transformations commonly used in synthesis.
- retrosynthetically analyze an organic molecule of interest and propose an efficient synthetic scheme.

Course Content:

Reaction Mechanisms: Review of reaction mechanisms, use of curved arrows to describe mechanisms; substitution reactions - S_N1, S_N2, and S_Ni mechanisms, neighboring group participation; the non-classical carbocation; elimination reactions - E1, E2, and E1cb mechanisms; review of electrophilic and other addition reactions of alkenes, electrophilic and nucleophilic aromatic substitutions, and nucleophilic addition reactions of aldehydes and ketones. Physical Organic Chemistry: The Hammett equation: applications, free energy diagrams; failures and modifications Hammett equation; Yukawa – Tsuno equation and its applications. Taft equation. steric effects in organic reactions, solvent effects, conformational effects, Curtin-Hammett principle; isotope effects, stereo-electronic effects. Organic Synthesis: Retrosynthetic analysis of organic molecules - disconnections and synthons; methods for forming C–C single and C=C double bonds; use of enolates, enamines, organolithium, -magnesium, and -copper compounds; stereoselectivity and regioselectivity; umpolung; 1,2-, 1,3-, 1,4-, and 1,5-dioxygenated systems, aldol and Claisen condensations, and the Michael addition; techniques of forming 3-, 4-, 5-, and 6-membered rings; coupling reactions; synthesis of C-N and C-O bonds; protecting groups; oxidations and reductions; examples of syntheses of somewhat complex molecules.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Organic Chemistry (J.E. McMurry)

(ii) Organic Chemistry (L.G. Wade Jr.)
(iii) Organic Chemistry (T.W.G. Solomons)
(iv) A Guidebook to Mechanism in Organic Chemistry (P.Sykes)
(v) Modern Methods of Organic Synthesis (W. Carruthers & I. Coldham)
(vi) Organic Synthesis: The Disconnection Approach (S. Warren & P. Wyatt)
(vii) Modern Organic Synthesis: An Introduction (G.S. Zweifel & M.H. Nantz).

Course Code and Title:

CH 3030- Advanced Practical Chemistry

Credit Value:

8C

Rationale:

This course is designed to provide advanced training in experimentation, use of instruments, data collection, analysis and presentation.

Pre-requisites:

First and second year chemistry core courses

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- use advanced instruments to study reactions.
- synthesize inorganic / organic compounds, purify and characterize them.
- quantify metal ions in complex matrices.
- record and analyse results of experiments.

Course Content:

Laboratory work conducted in the areas of Organic Chemistry, Inorganic Chemistry and Physical Chemistry.

Method/s of Evaluation:

Course is conducted in three modules. Each module is separately examined.

Recommended Readings:

(i) Vogel's Text book of qualitative inorganic analysis

(ii) Vogel's Text book of quantitative chemical analysis

(iii) Handouts issued in the laboratory.

Course Code and Title:
CH 3031- Symmetry in Chemistry
Credit Value:
1C
Rationale:
This course is designed to provide advanced knowledge on application of Group Theory in the prediction of molecular properties.
Pre-requisites:
None
Intended Learning Outcomes:
At the end of the course student should be able to:

- identify symmetry elements sand operations of a given molecule.
- assign a given molecule into a point group.
- apply the theories of irreducible and reducible representation.
- identify the mulliken symbol of a given irreducible representation.
- analyze the hybridization of a molecule/ bond by applying the molecular orbital theory.
- analyze the molecule given and predict the IR and Raman activity.

Course Content:
Introduction to symmetry: Symmetry elements (axis, plane, point) and operations (rotation, reflection, inversion and improper rotation), point groups, Elementary group theory; Matrix representation of symmetry operations, Reducible and irreducible representations, Analysis of IR and Raman spectra. Selection rules for IR and Raman. Symmetrically equivalent coordinates. Molecular orbital diagrams: Symmetry-adapted MO's using projection operators; Linear combination of atomic orbitals. Hückel molecular orbital calculations, σ and π bond formation (hybridization).
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Molecular Symmetry & Group Theory (Alan Vincent)
(ii) Introductory Group Theory for Chemists (G. Davidson)
(iii) Physical Chemistry (P. W. Atkins) (iv) Chemical Applications of Group Theory (F.A. Cotton).

Course Code and Title:

CH 3032- Computer programming in Chemistry

Credit Value:

3C

Rationale:

This course is designed to provide knowledge and training in developing computer programs to solve problems in chemistry.

Pre-requisites:

First year and second year chemistry core courses

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- apply programming knowledge and numerical methods to solve chemical problems at molecular level.

Course Content:

Programming with FORTRAN or C++, equation solving methods: Successive approximation method, Newton-Raphson method and Bisection method, numerical differentiation, numerical integration (Trapezoidal method, Simpson rule, Runge-kutta method). Matrix algebra; inversion, eigen values of a tri-diagonal matrix, reduction to tri-diagonal form, use of diagonalization routines. Curve fitting; linear and non-linear least square methods. Programming and software handling on Linux operating system, Statistical analysis of experimental data, molecular docking and conformational searching.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Quantum chemistry (D.A. McQuarrie)
(ii) Quantum chemistry (I. Levine)
(iii) Molecular modeling: Principles and applications (A.R. Leach)
(iv) Physical Chemistry (P.W. Atkins)
(v) Computer Simulation of Liquids (M.P. Allen & D.J. Tildesley).

Course Code and Title:
CH 3033 - Chemistry of Bio-molecules
Credit Value:
3C
Rationale:
This course is designed to provide an in depth knowledge on metabolic pathways.
Pre-requisites:
First year and second year chemistry core courses
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- classify biomolecules based on their biosynthesis.
- propose biosynthetic pathways leading to these natural organic molecules.
- demonstrate knowledge of the reactions of simple monosaccharides and the role of carbohydrates in biological systems.
- identify the use of some of these bio-molecules.

Course Content:
Building blocks and mechanisms in secondary metabolism: Primary and secondary metabolism, enzymes and coenzymes, Construction mechanisms in biological systems such as alkylation, Wagner-Meerwein rearrangement, Aldol and Claisen condensations, Schiff base formation, Mannich reaction, Transamination, reductions and oxidations in biosynthesis. Fatty acids and polyketides from acetate pathway: Saturated/Unsaturated fatty acids, Prostaglandins, Aromatic polyketides (Cyclization to give simple phenols and Anthraquinones), alkylation and coupling reactions of polyketides, Macrolides and polyether, Cyclization through Diels-Alder reaction to give statins. Aromatic amino acids and phenylpropanoids from shikimate pathway: Aromatic amino acids and simple benzoic acids, Lignans and lignin, Phenylpropanes, Benzoic acids from C_6C_3 compounds, Coumarins. Terpenoids and steroids from mevalonate pathway: Monoterpenes, Sesquiterpenoids, Diterpenoids, Sesterterpenoids, Triterpenoids, Carotenoids, Steroids. Steroid skeleton, numbering, conformations, main types of steroids and their biological functions, Important reactions and synthesis/partial synthesis of steroids. Biosynthesis of Alkaloids from amino acids: Chemical structure, Biosynthesis of alkaloids derived from ornithine, lysine, nicotinic acid, tyrosine, tryptophan, anthranilic acid, and histidine, Important reactions of alkaloids. Mixed biogenesis: Flavonoids and stilbenes, Meroterpenoids. Carbohydrates: Nomenclature and configurational relationship of monosaccharides, Fischer projection and Haworth formula, mutarotation, Reactions of anomeric and non-anomeric carbon atoms, Reactions of the hydroxyl groups, Amino sugars, Reducing and non-reducing sugars, Nature of di-, tri-, and polysaccharides.
Method/s of Evaluation:
End of semester examination
Recommended Readings:

(i) Medicinal Natural Products (Paul M. Dewick).

Course Code and Title:

CH 3054 – Nutritional and Clinical Biochemistry

Credit Value:

2C

Rationale:

This course aims to provide in-depth knowledge of nutritional requirement and its associated deficiency, and different biochemical basis behind cardiovascular diseases, diabetics, liver disorders, renal disorders etc., and their testing parameters, the interpretation of results, and the clinical applications of such testing in disease diagnosis. These testing parameters include proteins, enzymes, and metabolic products.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- assess vitamins as cofactors in enzymes.
- assess the importance of vitamin in diets.
- evaluate the role of specific minerals in nutrition.
- describe the principle involved in the measurement of analytes in the clinical biochemistry laboratory.
- outline how biochemical analysis can be employed to differentiate between normal and diseased conditions.
- perform practical biochemical analysis of clinical samples.
- perform data handling exercises associated with biochemical analysis.

Course Content:

Energy and protein requirements. Fat soluble vitamins (Vitamin A, D, E and K) and Water-soluble vitamins (mainly folate and vitamin B12)- sources, metabolism, biochemical function, Method/s of Evaluation, causes and consequences of deficiency and excess. Trace elements: Iron- deficiency and consequences, bioavailability, non-haem iron and haem iron, enhancement of absorption, stages in development of deficiencies, prevention of deficiencies. Iodine- metabolism, function of thyroid hormones, Method/s of Evaluation of thyroid function. Zinc, Selenium and fluoride. Diet and chronic disorders- obesity, diabetes mellitus type 2, cardiovascular diseases, role of lipoproteins in atherogenesis and thrombosis, role of diet; Introduction to Clinical Biochemistry. Liver disorders, renal disorders, IHD. Clinical tests versus cost. Understanding the purpose of each clinical test, accuracy, quality control, automation. Basis of common laboratory tests- blood glucose, albumin, urea, lipid profile, cardiac markers etc. Special investigations.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Biochemistry with clinical correlations (Thomas M. Devlin)
(ii) Clinical Chemistry (William J. Marshall).

Course Code and Title:
CH 3071 – Pharmaceutics I
Credit Value:
3C
Rationale:
Pharmaceutics is a vital component in pharmacy education and provides an understanding in how to formulate a drug that can be delivered to a patient safely, effectively and conveniently. This course equips the students on how drugs are formulated and the importance of various dosage forms. From the fundamental knowledge of pharmaceutical dosage forms the students will get an understanding that different dosage forms produce different therapeutic outcomes and pharmacokinetics. This course will equip students with the skills to work in the pharmaceutical industry.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- explain why pharmaceutical formulation, dosage form design and manufacturing are important in ensuring that patients receive the best possible therapy.
- describe the principles of Good Manufacturing Practice, Quality Assurance, Quality Control, and the philosophy of Quality by Design.
- apply key aspects of the physical chemistry of solutions, particularly those in water, and their relevance to the formulation of medicines.
- comprehend fundamental colloid science and be able to discuss its relevance to the development of effective medicines.
- explain key aspects of surface science and its relevance to the development of effective medicines.
- discuss how physical chemistry can be exploited to optimize the formulation of liquid and semisolid pharmaceutical products, including solutions, suspensions, emulsions, creams, gels, and ointments, taking into account both patient-related and drug-related factors.
- apply the fundamentals of material science and its relevance to the design and manufacture of medicines.
- explain how conventional oral solid dose formulations are developed, formulated, produced and tested, taking into account relevant patient-related and drug-related factors.
- show competence in analyzing and interpreting numerical data.
- work both independently and in a group.
- demonstrate the ability to communicate scientific concepts clearly and concisely, both orally and in writing.

Course Content:

Introduction to dosage forms: Good manufacturing practice: Design of dosage forms; Pharmaceutical solvents: Quality of water : Detailed study from the view point of water as universal pharmaceutical vehicle, Non aqueous solvents. Solutions: Solubility, problems associated with prediction of solubility, methods of increasing solubility; cosolvents, complexation, salts, surfactants. Interfacial phenomena; Interfaces and surfaces; surface and interfacial tension and their measurement, surface free energy, contact angles and their uses; Adsorption equation, factors affecting adsorption isotherms; Pharmaceutical applications of adsorption phenomena; surface films, film balance studies and their uses in pharmacy; Rheology: solids, liquids, semi-solids, colloids, molecular weight. Equipment for viscosity measurement, non-Newtonian systems, viscoelastic properties; Pharmaceutical Technology: Bulk Characteristics, Micrometrics, Non-sterile monophasic systems, Dispersed systems, Emulsions, Solid dosage forms, Tablets, Coated tablets, Capsules, Soft gelatin capsules, Semisolid dosage forms: Creams, Gels and Jellies.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Bently's Text book of pharmaceutics (E.A. Rawlins)
(ii) Pharmaceutical practice (D.M. Collett and M. Aulton)
(iii) Ramington's Pharmaceutical science (A. R. Gennaro)
(iv) Pharmaceutics: The science of dosage from design (M. Aulton)
(v) Good manufacturing practice and inspection by World health organization, Pharmaceutical engineering (K. Sambamurthy).

Course Code and Title:

CH 3073 – Anatomy and Physiology

Credit Value:

3C

Rationale:

Study of Anatomy and Physiology enables students to identify the human form and function from the levels of cells, tissues, organ systems and the whole body. By learning Anatomy and Physiology the organ structures, their function and how they interact is an essential for students following the B.Sc Pharmacy special degree course. This course unit enables students to understand how human disease originate and understand mechanisms of treatment.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

ANATOMY

- use anatomical terminology to identify and describe locations of major organs of each system covered.
- explain interrelationships among molecular, cellular, tissue and organ functions in each organ system of the human body.
- list the major components of each organ system and describe the main functions of each organ system. Relate to physiology of the particular system.

PHYSIOLOGY

- explain interrelationships among molecular, cellular, tissue and organ functions in each system.
- state the functions of each organ system of the body, explain the mechanisms by which each functions, and relate the functions and the anatomy and histology of each organ system.
- describe the interdependency and interactions of the human organ systems.
- explain contributions of organs and systems to the maintenance of homeostasis.
- identify causes and effects of homeostatic imbalances.
- explain the integrated responses of the organ systems to physiological and pathological stresses.
- develop the foundation to understand pharmacology.

Course Content:

ANATOMY

Cells and Tissues, Basic embryology and genetics, Anatomy of the locomotor system. Anatomy of the cardiovascular system, Anatomy of the reticuloendothelial and lymphatic system, Anatomy of the respiratory system, Anatomy of the endocrine system, Anatomy of the nervous system, Anatomy of the gastrointestinal system. Anatomy of the special sense organs and the skin, Anatomy of the renal system. Anatomy of the reproductive system.

PHYSIOLOGY

Introduction to homeostasis and body fluids, Blood and haemostasis, Introduction to defence mechanisms and hypersensitivity reactions, Physiology of excitable tissue (nerve, muscle and neuromuscular junction), Autonomic nervous system, Physiology of the cardiovascular system, Physiology of the respiratory system, Physiology of the renal system and H^+ balance, Physiology of the gastrointestinal system, Physiology of the nervous system, Physiology of the endocrine system, Physiology of the reproductive system.

Method/s of Evaluation:

End of year examination

Recommended Readings:

ANATOMY

(i) Human Anatomy - Regional and Applied Dissection and Clinical (B. D. Chaurasia).

PHYSIOLOGY

(i) Review of Medical Physiology (W. F. Ganong).

Course Code and Title:
CH 3074 – Pharmacology I
Credit Value:
3C
Rationale:
Study of pharmacology enables students to identify the interaction of different medicines with the human body and their action with respect to treatment and mitigation of disease. Knowledge of Pharmacology enable students to obtain knowledge of the stages in the development of new drugs, the application of drugs as therapeutic agents, the beneficial and adverse effects of drugs in individuals and society. Knowledge of Pharmacology prepares the students to practice as pharmacists by providing appropriate information regarding medicine use.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- acquire a basic understanding of pharmacodynamics, pharmacokinetics, pharmacological aspects of the autonomic nervous system, clinical trials, drug information and adverse reactions to drugs.
- explain the clinical pharmacology (mechanism of action, pharmacokinetics, indications, cautions, contra-indications, side effects, dose, dosage forms, other relevant information) of the common drugs that are acting on the cardiovascular system, and the endocrine system of the body along with drugs prescribed for infections and parasitic diseases.
- demonstrate that the student is able to acquire information about the doses, dosage forms, administration details, other technical information about drugs.
- demonstrate that the student is able to acquire information about drugs and give appropriate advice to patients and care givers about their use.

Course Content:
Introduction to pharmacology, Sources of drug information, Pharmacist's role in providing drug information, Ethics, Compliance (adherence), Drug discovery and development, Clinical trials, Adverse drug reactions (ADR), Principles of drug allergy and role of adrenaline in the treatment of anaphylaxis, Routes of drugs administration, Pharmacokinetics, Pharmacodynamics, Autonomic nervous system (ANS) (objectives to cover basic anatomy and physiology of ANS and medicines acting on ANS - parasympathomimetics, anticholinergics, anticholinesterase, sympathomimetics and adrenergic receptor blockings), Drugs in angina, Drugs in hypertension, Anticoagulants, fibrinolytics and antiplatelet drugs, Inotropics and antiarrhythmic drugs, Drugs in hyperlipidaemia, Diuretics, Principles of antimicrobial chemotherapy, chemoprophylaxis and use of antimicrobials in combination, Penicillins, Cephalosporins and Macrolides, Aminoglycosides, Chloramphenicol and Tetracyclines,

Sulphonamides, Urinary antiseptics and Quinolones, Antimycobacterial drugs, Other antibacterial agents, Antifungal drugs, Antiviral drugs, Antimalarial drugs, Drugs in helminthiasis, Drugs in amoebiasis, giardiasis and trichomoniasis, Hypothalamic and pituitary hormones and their synthetic analogues, Vitamin D and analogues, Thyroxine and anti-thyroid drugs, Ovarian stimulants, Oestrogens, progestogens and androgens, Hormonal contraception, Corticosteroids, Insulin, Insulin - Skills Session , Oral hypoglycaemic drugs.

Method/s of Evaluation:

End of year examination

Recommended Readings:

(ii) Clinical Pharmacology (P. N. Bennett and M. J. Brown)
(iii) Pharmacology (H. P. Rang and M. M. Dale)
(iv) Foundations of Pharmacology (Professor R. L. Jayakody)
(v) The British National Formulary (v) The Sri Lanka Prescribers (Journal).

Course Code and Title:

CH 3075 – Practical Pharmacy

Credit Value:

8C

Rationale:

This practical course will equip the students with hands on experience in biomedical test methods, analysis of different dosage forms and formulation of different dosage forms. These skills will be beneficial for the students to work in a range of employment areas and provide opportunities to work in the pharmaceutical industry.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- recognize different biomedical testing methods.
- evaluate physicochemical properties of raw materials as well as various dosage forms.
- analyze active ingredient content in different dosage forms.
- prepare solid, semisolid, liquid dosage forms.
- Identify problems, explore potential strategies in designing, implementing and evaluating viable solutions.

Course Content:

Biochemistry, Pharmaceutics, Pharmaceutical chemistry, Pharmaceutical Analysis & Nuclear Pharmacy, Pharmaceutical Microbiology.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Practical pharmaceutical chemistry part 1 and part 2 (Backett and Stenlake)
(ii) Jenkins' Quantitative pharmaceutical chemistry (Knevil and Digangi)
(iii) Pharmaceutical chemistry volume 2 (drug analysis) (Roth, Eager and Troschutz)
(iv) The British Pharmacopoeia, The United States Pharmacopoeia
(v) Handouts issued in the laboratory.

Course Code and Title:
CH 3076 –Microbiology in Pharmacy
Credit Value:
2C
Rationale:
This course provides knowledge of microbes and its relation in the manufacture of pharmaceutical products. This equips the students with the knowledge of how to minimize contamination during the manufacturing process of pharmaceutical formulations. Microbiology in pharmacy will provide the students with the skills to work in the pharmaceutical industry.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- describe different groups of microorganisms and their role in causing diseases.
- explain use of microorganism in pharmaceutical industry and spoilage of pharmaceuticals.
- identify physical and chemical treatments in controlling microorganism in pharmaceuticals.
- explain the test methods used to determine contamination in pharmaceutical formulations.
- describe pharmaceuticals generated by microorganisms.

Course Content:
The nature of microorganisms and their role in causing diseases, their use in pharmaceutical and spoilage of pharmaceuticals; microbial contamination of pharmaceuticals and the associated hazards; The physical and chemical agents used to control microorganisms in pharmaceuticals; Microbiological control methods used in manufacture of pharmaceuticals; microorganism resistance development antimicrobial agents; Pharmaceutical application of microbiological techniques: Antimicrobial activity, Counting & identification of micro-organisms in a pharmaceutical product, Sterility and pyrogen testing to test the preservative efficacy, Challenge tests: to test the preservative efficacy; Microbiological quality assurance: Limits and Standards: official & unofficial, Methods used to control microbial contamination of products: Control of raw materials, Formulation aspects, Good manufacturing practice (GMP), Evaluation of a microbial quality of a pharmaceutical product; immunological products; Microbiologically generated pharmaceuticals: vitamins, enzymes, antibiotics, alcohol, insulin, microbiology of water, microbiology of air, major microbials (bacterial, protozoal fungal, viral).
Method/s of Evaluation:
End of semester examination

Recommended Readings:

(i) Disinfection and sterilization (G. Sykes)

(ii) Medical microbiology (Cruicshank).

Course Code and Title

CH 3090 – Practical Computational Chemistry

Credit Value:

8C

Rationale:

This course is designed to provide advanced training in experimentation, use of instruments, data collection, analysis, use of computational software and presentation.

Pre-requisites:

First and second year chemistry core courses

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- use experimental techniques to collect data.
- handle equipment in chemistry laboratory.
- use computational chemistry software to solve problem in Chemistry / Biochemistry.
- calculate molecular properties using software.

Course Content:

Practical conducted in the area of computer applications to solve chemical problems.

Method/s of Evaluation:

Course is conducted in four modules. Each module is separately examined.

Recommended Readings:

Handouts issued in the laboratory.

Course Code and Title

CH 3901 –Bioanalytical Chemistry I

Credit value:

2C

Rationale:

This course unit is designed to provide fundamental knowledge of various bio-analytical methods.

Pre-requisites: None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain various advanced analytical methods used for bioanalysis.
- select and construct proper analytical methods for the analysis of biomolecules.
- apply statistical methods in chemical analysis.

Course Content:

Expression of concentration and composition, unit conversion, buffer action and buffer preparation, measurements in analytical chemistry, significant figures, error in chemical analysis, basic statistical parameters in analytical chemistry, types of errors, random and systematic errors, types of sampling methods, standards and standard sample preparation, external and internal calibration and calibration plots, internal and external standards, standard addition method, advance titrimetric methods for bioanalysis, optical spectroscopic methods for bioanalysis (AAS, UV-Vis, FTIR, Raman and Fluorescence), principles of liquid and gas chromatography, basic chromatographic theory, gas and liquid chromatographic techniques for bioanalysis.

Method/s of Evaluation:

End of semester examination (70%) and continuous Method/s of Evaluations (up to 30%)

Recommended Readings:

(i) Bioanalytical Chemistry (A. Manz, P. Dittrich, N. Pamme, D. Iossifidis)

(ii) Bioanalytical Chemistry (S. Mikkelsen, E. Corton)

(iii) Fundamentals of analytical (D. Skoog, D. M. West, F. Holler)

(iv) Principles of instrumental analysis (D. Skoog, F. Holler, S. Crouch).

Course Code and Title:
CH 4001 – Research Project
Credit Value:
8C
Rationale:
This course is designed to provide the opportunity for students to plan and execute a research project independently.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- carry out a comprehensive literature search under a given research problem.
- design and implement a suitable experimental / theoretical procedure.
- critically analyze any data generated.
- write a comprehensive account of the literature survey, experimental procedure and analysis of results, and discussion.
- effectively communicate any findings and defend the work in a professional manner.

Method/s of Evaluation:
End of year evaluation of thesis and viva voce

Course Code and Title:
CH 4002 – Seminar and Essay
Credit Value:
3C
Rationale:
This course is designed to provide the opportunity for students to improve their comprehension and writing skills.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- read and understand scientific publications.
- critically and carefully analyze the information.
- extract the core essence of published research.
- present the information in a comprehensive and interesting manner to a large and diverse audience.
- effectively answer questions asked.
- explain / answer questions using the knowledge gathered during the programme.
- be up-to-date on current developments in the field of Chemistry.
- write a comprehensive account, elaborating on a current topic in Chemistry.

Method/s of Evaluation:
Seminar - End of semester evaluation
Essay - End of year evaluation

Course Code and Title:
CH 4003 – General Paper
Credit Value:
3C
Rationale:
This course is designed to test the application of basic knowledge in all fields of chemistry.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:
- apply the basic principles in problem solving in all areas of Chemistry.

Method/s of Evaluation:
End of year examination

Course Code and Title:

CH 4004 – Optional Topics

Credit Value:

4C

Rationale:

This course is designed to provide exposure and knowledge on the latest developments in the field of chemistry.

Pre-requisites:

None

Course Content:

Current topics of interest

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- be up-to-date on current developments in the field of Chemistry.
- be able to apply the knowledge gathered to analyze and explain more advanced research findings.

Method/s of Evaluation:

End of semester examination

Course Code and Title:
CH 4005 - Advanced Organic Chemistry
Credit Value:
3C
Rationale:
This course is designed to provide advanced knowledge on radical reactions involving organic molecules and their interaction with electromagnetic radiation.
Pre-requisites:
CH 3029
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- recognize and classify pericyclic reactions.
- predict the feasibility and the stereochemical outcome of a pericyclic reaction.
- utilize pericyclic and free radical reactions in the synthesis of organic molecules.
- apply principles in mechanistic photochemistry.
- recognize, classify, and describe the chemical properties of aromatic heterocyclic compounds.
- describe methods of synthesis and products of reactions of aromatic heterocyclic compounds.

Course Content:
Pericyclic Reactions: Definition and classification of pericyclic reactions; electrocyclic, cycloaddition, sigmatropic, cheletropic and ene reactions; topology of orbital overlap; molecular orbital correlation diagrams; frontier molecular orbital theory, aromatic transition state theory, generalized selection rule for pericyclic reactions; selected examples of applications in organic synthesis. Organic Photochemistry: Selection rules for electronic excitation. Electronic states, Quantum yield, excitation sources, filters, Deactivation paths of excited states, Kinetics of photophysical processes, fluorescence and phosphorescence Excimers and exciplexes, Energy transfer and sensitization. Principles of photo-induced electron transfer: Redox properties of excited states, Thermodynamics of photoredox reactions, Dynamics of electron transfer processes, Photochemistry of carbonyl compounds, photochemical deconjugation, photochemical additions with and without sensitizer; Buchi-Paterno reaction. Photoisomerization of C=C, N=N, C=N compounds, photostationary state, photochromism, photochemistry of aromatic compounds, Di-⍰-methane rearrangement, photoremovable protecting groups in organic synthesis, resins containing light sensitive chromophores, industrial photochemical synthesis. Free Radical Reactions: Structure and reactivity of radicals; generation of radicals; mechanisms of radical reactions; free radical additions, substitutions, and rearrangements; use of radicals in cyclisation; radical oxidations, combustion, oxidative rancidity, etc.; stable radicals and radical scavengers; radicals in carbohydrate and nucleoside chemistry. Aromatic Heterocycles: Review of Hückel's Rules; importance and natural occurrence of heteroaromatic compounds; nomenclature; general

principles of heterocyclic synthesis; chemistry of pyridine; diazines; quinoline and isoquinoline; six-membered rings containing O - pyriliums, pyrones, benzopyriliums and benzopyrones; aromaticity and reactivity of five-membered heterocycles - pyrrole, thiophene, and furan; pyrazole, imidazole, and other azoles; indole and purines; unusual heterocyclic systems - sydnones, etc.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Organic Chemistry (J. Clayden, N. Greeves, S. Warren and P. Wothers)
(ii) Organic Chemistry (L.G. Wade Jr.)
(iii) Organic Chemistry (T.W.G. Solomons)
(iv) Advanced Organic Chemistry, Parts A & B (F.A. Carey and R.J. Sundberg)
(v) Modern Photochemistry (N.J. Turro)
(vi) Heterocyclic Chemistry (J.A. Joule and K. Mills).

Course Code and Title:

CH 4006 – Biochemistry

Credit Value:

3C

Rationale:

This course is designed to provide advanced knowledge on mechanistic aspects of enzymatic reactions and the role of metal ions in biologically important processes.

Pre-requisites:

First year and second year chemistry core courses

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- elucidate the structures of proteins.
- apply kinetic principles (Michaelis-Menton kinetics) to enzyme catalyzed reactions.
- propose reaction mechanisms using inhibitor studies and enzyme kinetics.
- explain the role of metal ions in biological processes using the principles in Inorganic Chemistry (such as, Crystal Field Theory).

Course Content:

Amino acids and proteins, enzymes as biological catalysts, extraction and purification of proteins, determination of sequence of an protein using chemical and enzymatic methods, chemical synthesis of a peptide, Synthesis on a Solid support, Importance of secondary, tertiary and quaternary structure in enzyme catalysis, Enzyme catalysis, Importance of active site residues in enzyme catalysis, Function of Coenzymes, Enzyme Kinetics, Bioenergetics: Application of energy relationships and electrochemistry to biological systems, Role of high energy compounds, Chemical basis for large free energy of "hydrolysis" of ATP, PEP,1,3-bisphosphoglycerate, Acetyl Coenzyme A. Metabolic pathways, Regulation of pathways, Metabolic disorders and inborn errors of metabolism. Bioinorganic chemistry: Structure and function of oxygen transport and storage proteins (hemoglobin, myoglobin) and electron transfer proteins (cytochromes, iron-sulfur proteins, blue copper proteins) and the related principles of chemistry, Selection of zinc for biological systems, role of zinc in superoxide dismutase, zinc fingers and carbonic anhydrase.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Biochemistry (A.L. Lehninger)

(ii) Biochemistry (C.K. Mathews, K.F. van Holde)

(iii) Enzyme kinetics and catalysis (S.A. Deraniyagala)

(iv) The principles of bioinorganic chemistry (S. J. Lippard, J. M. Berg)

(v) The biological chemistry of the elements: The inorganic chemistry of life (J. J. R. F. da Silva, R. J. P. Williams)

(vi) Biochemistry (D. Voet, J.G. Voet).

Course Code and Title:
CH 4007 – Advanced Physical Chemistry
Credit Value:
3C

Rationale:
This course is designed to provide in depth theoretical knowledge in thermodynamics, statistical thermodynamics, kinetics and electrochemistry.
Pre-requisites:
First year and second year chemistry core course units
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- derive bulk thermodynamic properties from molecular properties.
- derive relevant thermodynamic parameters using different thermodynamic ensembles.
- correlate quantum mechanical results with thermodynamic parameters.
- explain the Third Law of Thermodynamics and calculate third law entropies.
- describe the background of chemical potential.
- analyze thermodynamics of mixing.
- demonstrate how the amount of a solute affect colligative properties of a solvent and perform calculations involving these colligative properties.
- apply advanced kinetic principles in solving problems.
- predict thermodynamic parameters involved in activation of molecules.
- predict quantitatively, rates of reactions using partition functions.
- derive and apply mass transport equations.
- derive Butler-Volmer equation and apply it in problem solving.
- calculate the corrosion rate using appropriate equations.

Course Content:
Statistical Thermodynamics: statistical states, complexions, axiom of equal probability of complexions, distribution of molecules/atoms in energy states, degeneracy, independent identical distinguishable particles. Sterling's approximation. Boltzmann distribution, Molecular partition function and interpretation, translational, vibrational, rotational, electronic and nuclear partition, Corrected Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Specific heats of solids, Einstein, Debye models. Specific heats of gases. Equilibrium constant, diatomic molecules, Ortho-para equilibrium, Canonical, microcanonical, and grand canonical ensembles. Advanced Thermodynamics: Third law of thermodynamics, third law entropies, standard molar Gibbs function, chemical potential. Real gases: fugacity, standard states, open systems, partial molar quantities, Thermodynamics of mixing: colligative properties, mixtures of volatile liquids, V-P diagrams, distillation, Real solutions, activities. Chemical Kinetics: Simple collision theory: effective cross section, Transition State Theory:

Potential energy surfaces, trajectories, comparison with collision theory, thermodynamic treatment of reaction rate. Unimolecular reactions: Lindemann theory, Hinshelwood modifications, RRK and Slater theories. RRKM theory-basics only, reactions in solution. Advanced Electrochemistry: Nature of the electrode solution interface: capacitance and charge of an electrode, brief description on electrical double layer, double layer capacitance and charging current. Mass transfer controlled reactions: modes of mass transfer (migration, diffusion, convection) steady state mass transfer (diffusion) equations. Liquid junction potentials: conductance, transference number, Hittorf method, Moving boundary method, mobility, types of liquid junctions, calculation of liquid junction potentials, minimization of liquid junction potential. Kinetics of Electrode Reactions: electron transfer at interface, Butler-Volmer equation, exchange current density, overpotential, concentration overpotential, Tafel plots, polarizability, effects of mass transfer. Corrosion: polarization and corrosion rates, causes of polarization, Hydrogen overpotential, polarization diagrams of corroding metals, influence of polarization on corrosion rate, calculation of corrosion rates from polarization data. Double layer structure in detail: Thermodynamics of the double layer, electrocapillary equation, surface excesses and electric parameters, excess charge and capacitance, reactive surface excesses, models for double layer structure (Helmholtz, Gouy-Chapman, Stern).

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Statistical mechanics (D.A. McQuarrie)

(ii) Physical Chemistry (P.W. Atkins)

(iii) Photochemistry (R.P Wayne)

(iv) Chemical kinetics (K.J. Laidler)

(v) Physical Chemistry (D. A. McQuarrie)

(vi) Electrochemical methods: Fundamentals and applications (A.J. Bard, L.R. Faulkner)

(vii) Corrosion and corrosion control: an introduction to corrosion science and engineering (R. W. Revie, H. H. Uhlig).

Course Code and Title:

CH 4008 – Advanced topics in Chemistry

Credit Value:

3C

Rationale:

This course is designed to provide in depth knowledge in crystallography and material science.

Pre-requisites:

First year and second year chemistry core course units

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- demonstrate how an approximate solution of structure is deduced using crystallographic data.
- identify problems associated with the crystal structure determination process.
- compare and contrast different methods for crystal structure determination.
- identify space symmetry in a crystal.
- derive the geometry of electron deficient clusters.
- explain metal-metal bonding and determine the geometry of metal clusters.
- predict synthetic routes and reactivity of clusters.
- classify solids into different crystalline systems.
- predict electronic and thermal properties of solids.
- apply surface analytical techniques to elucidate surface structure and composition.

Course Content:

X-ray crystallography: Approximate solution of structure, intensities to structure factors. Fourier synthesis. Phase problem, Patterson synthesis. Heavy atom method. Direct method. Refinement, R factor. Fourier refinement. Least squares refinement. Estimation of errors. Comparison with neutron and electron diffraction. Identification of space symmetry in a crystal.

Clusters and cage molecules: clusters in elemental state. Structure of cluster compounds: classification, nomenclature. Bonding in clusters: molecular orbital theory, frontier molecular orbitals, electron deficient clusters; Lipscomb's Styx rules, Polyhedral skeletal electron pair theory, metal-metal bonds and metal clusters, structure and bonding, isolable principle, synthetic routes to clusters, reactivity of clusters. Solid state and surface analytical techniques: Crystal growth structure, defects and surfaces. Band theory of solids, Primitive vectors, 2D symmetries, Unit cell, Lattice planes, Miller indices, Surface processes: X-ray photoelectron spectroscopy, Auger spectroscopy, ion scattering spectroscopy, low energy electron diffraction, field emission microscopy, field ionization microscopy, electron microscopy, electron energy loss spectroscopy, atom-probe film, scanning tunneling microscopy, atomic force microscopy.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Crystal Structure Analysis (J.P Glusker and K.N. Trueblood)
(ii) Fundamentals of Crystallography (C. Giacovazzo)
(iii) X-Ray Crystallography (G.L. Glasser)
(iv) Physical Chemistry (P.W. Atkins
(v) Instrumental methods of analysis (H.H. Willard, L.L. Merritt Jr., J.A. Dean, F.A. Settle Jr)
(vi) Modern spectroscopy (J.M. Hollas)
(vii) Principles of Surface Chemistry (G. Somorjai)
(viii) Physical Chemistry of Surfaces (A.W. Adamson)
(ix) Introduction to solid state physics (C. Kittel).

Course Code and Title:
CH 4070 – Pharmaceutics II
Credit Value:
3C
Rationale:
Pharmaceutics is important to formulate a drug that can be delivered to a patient safely, effectively and conveniently. This course will provide a thorough knowledge on sterile dosage forms, aerosols and their manufacturing processes. This will equip the students with the skills to work in the biomedical and pharmaceutical industry.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- describe the types and properties of microorganism relevant to sterile product manufacture.
- discuss the key principles of pharmaceutical clean room design, validation and operation.
- explain how parenteral and ophthalmic preparations are designed, developed, formulated, produced and tested, taking into account relevant patient-related and drug-related factors.
- explain how controlled-release drug delivery systems are designed, developed, formulated, produced and tested, taking into account relevant patient-related and drug-related factors.
- discuss how physical chemistry can be exploited to optimize the formulation of aerosols, taking into account both patient-related and drug-related factors.
- describe key aspects of chemical kinetics, with a focus on drug dissolution and degradation, and apply mathematical models to determine the kinetics of a process.
- explain the major processes which can cause drug degradation and how the stability of medicines can be measured and predicted.
- discuss the concepts of biopharmaceutics, pharmacokinetics, pharmacodynamics, and mechanisms of drug transport.
- analyse and solve complex problems, demonstrating the ability to critically evaluate datasets and draw sensible conclusions in the absence of complete data.
- work both independently and in a group, showing initiative, innovative thinking, and taking a leadership role where necessary.
- effectively communicate complex information, both orally and in writing.

Course Content:
Sterile Delivery System; Parenteral Preparations; Design of facilities and environmental control; Personnel; Ophthalmic products; Controlled drug delivery; Designing of Drug Delivery Systems; Aerosols; Chemical Kinetics, Drug Stability and Stability Prediction;

Biopharmaceutics; Mechanisms of drug transport; Physical Pharmacy: Solubility of drugs, ionization of drugs in solution, diffusion of drugs, drug stability.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) The theory and practice of industrial pharmacy (L.Lachman, H.A. Lieberman and Kanig)
(ii) Physical pharmacy (Alfred, James and Arther)
(iii) Pharmaceutical dosage forms and drug delivery systems (H.C. Ancel, Papovich and Allen)
(iv) Applied biopharmaceutics and pharmacokinetics (L. Shergel, B.C. Andrew and Andrew B.C. Yu).

Course Code and Title:

CH 4071 – Pharmacology II

Credit Value:

3C

Rationale:

Pharmacology II is the continuation of the course unit CH 3074 Pharmacology I. This unit expands student knowledge on Pharmacology which is an essential component in Pharmacy education enabling students to practice as competent Pharmacist.

Pre-requisites:

CH 3074

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain the clinical pharmacology (mechanism of action, pharmacokinetics, indications, cautions, contra-indications, side effects, dose, dosage forms, other relevant information) of the common drugs acting on different systems of the body including the gastrointestinal tract, respiratory system and nervous system.
- demonstrate that the student is able to acquire information about the doses, dosage forms, administration details, other technical information about drugs.
- demonstrate that the student is able to acquire information about drugs and give appropriate advice to patients and care givers about their use.
- be aware of the cost of medicines.
- develop a foundation on which the student can build enabling him/her to be a competent professional in the future and be capable of continued education in the field.

Course Content:

Oral hypoglycaemic drugs, Drugs used in peptic ulcer disease, Solutions for correcting water, electrolyte and acid – base disturbances (Oral rehydration salt (ORS) and Intravenous fluids), Laxatives and antidiarrhoeals, Antiemetics, Introduction to neuropsychopharmacology, Drugs used in epilepsy, Drugs used in Parkinson disease, Strong analgesics, Local and general anaesthetics, Drugs in migraine, Drugs used in schizophrenia, Drugs used in depression and mania, Psychostimulants, Anxiolytics, sedatives and hypnotics, Drugs used in the treatment of asthma, Skills session on inhalers, Antihistamines and cough remedies, Paracetamol and non-steroidal anti-inflammatory drugs (NSAIDs) including aspirin, Cytotoxic drugs, Disease modifying anti-rheumatic drugs (DMARDs), Vaccines and sera, Drugs in the treatment of anaemia, Vitamins and minerals, Pharmacology of alcohol (ethyl alcohol and methyl alcohol), Systemic antidotes, chelating agents, drugs used in management of poisoning, Drugs in eye and ear disease, Drugs used in skin disease, Prescribing in children, Prescribing during pregnancy, Prescribing in renal disease, Prescribing in liver disease, Drug Interactions, Drug registration, schedules and post-marketing surveillance, Concept of essential drugs (essential medicines).

Method/s of Evaluation:

End of year examination

Recommended Readings:

(i) Clinical Pharmacology (P. N. Benett and M. J. Brown)

(ii) Pharmacology (H. P. Rang and M. M. Dale)

(iii) Foundations of Pharmacology (Professor R. L. Jayakody)

(iv) The British National Formulary (v) The Sri Lanka Prescribers (Journal).

Course Code and Title:

CH 4073 – Advanced Pharmaceutical Chemistry II

Credit Value:

2C

Rationale:

Pharmaceutical chemistry will provide the students with a broad knowledge in chemistry, biochemistry, causes behind diseases and the mode of action of drugs. This course covers drugs designed for different biological systems in the body and the synthesis of these drugs. Advanced pharmaceutical chemistry II provides the students with the skills to work as a pharmaceutical chemist giving a wide range of employment opportunities such as the pharmaceutical industry, medical and biomedical areas.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- recognize representative drugs acting on the cardiovascular system, central nervous system, respiratory tract, antiemetic drugs, antithyroid drugs, and vitamins and their respective mechanisms of action.
- explain structure-activity relationships of some selected drugs.
- explain mechanisms to synthesize drugs.

Course Content:

Drugs acting on cardiovascular system: Antiarrhythmics, antianginals, antilipidemics, ACE inhibitors, antihypertensives, anticoagulants; Drugs affecting the Central Nervous System: The structure-activity relationships and molecular conformation of CNS transmitter substances, analgesics, antiepileptics, sedatives, hypnotics, antipsychotics, anti-Parkinson agents, antidepressants, stimulants; Drugs acting on the respiratory tract: Aminophylline, Beclametasone, Epinephrine, Salbutomol; Antiemetic drugs: Dexamethasone, haloperidol, metaclopramide, prochlorperazine; Antithyroid drugs: Iodide, levothyroxine, methimazole; Antihistamines: Cimetidine, promethazine, ranitidine, chlorpheniramine, famotidine ; Chemistry of vitamins: Vitamin A1, Vitamin B1, B2, B6, B12, folic acid, vitamin C, vitamin K, vitamin D, vitamin E; Stereoisomerism and pharmacological activity.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Bently and Driver's textbook of pharmaceutical chemistry (L.M. Atherden)
(ii) Modern inorganic pharmaceutical chemistry (C.A. Disher, T. Medwic and L.C. Baily)
(iii) Physical Pharmacy (A. Martin, P. Bustamante and A.H.C. Chen)
(iv) Hand book of Pharmaceutical excipients (A. Wade and P.J. Walker).

Course Code and Title:

CH 4074 – Quality Control, Statistics and Computer Applications

Credit Value:

3C

Rationale:

This course focuses on three important areas of the pharmaceutical industry which are quality control, statistics and computer applications. Quality control will provide the students with the knowledge of the various processes involved in marketing a safe drug which is therapeutically active that maintains consistent performance. Statistics is a valuable tool in the pharmaceutical industry. This section will equip the students with the understanding in designing experiments to evaluate drug activity and designing and analyzing clinical trials. The computational aspect will develop the skills to apply computer programs to model, predict and analyze the functions of potential drug structures and their interactions with biologically important targets. This course provides sound background and skills to work in the pharmaceutical industry as well as biomedical areas.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- employ quality control concepts in the pharmaceutical industry.
- illustrate the importance of quality assurance in the pharmaceutical industry.
- analyze the steps involved in the quality assurance process.
- design pharmaceutical related experiments using statistical techniques.
- appraise the statistical methods used in different experiments.
- employ computer aided drug design techniques for drug discovery.
- calculate physico-chemical properties of drug compounds through computational methods.
- illustrate how a pharmacophore is derived and how it is used to design new drugs by computational modelling.
- estimate the efficacy of drug molecules using computational docking tool.

Course Content:

Quality assurance of pharmaceuticals: pharmacopoeial monograph, literature collection, data handling and expression of analytical results; Documentation and record keeping; Official, international and national guidelines of testing parameters of pharmaceuticals; sources of quality variation; Development of quality specifications; Statistical methods in pharmacy and quality assurance; Presentation of sample data; measures of central tendency; Probability distributions; Sampling; Estimation; Confidence intervals for the mean for the difference of two means (independent populations). The pairing of samples, confidence intervals of paired data. Confidence intervals for the difference of two populations (independent populations) with application; Hypothesis testing; Regression theory; Statistical design of experiments and statistical evaluation of data: Clinical trials, planning (protocol design), microbial testing, statistical design of experiments, statistical evaluation of data. Validation of analytical procedures: Standardization of reagents, characteristics of analytical procedures, use of chemical reference substances. In-process control; Quality Control of finished pharmaceutical products; Computer applications: Spread sheet applications, Molecular modeling in drug discovery, Deriving and using pharmacophores, molecular docking, structure based methods to identify lead compounds, quantitative structure activity relationships.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Gaussian 98 users reference (Afrisch, M.J Frisch) (ii) Microsoft Excel users' manual.

Course Code and Title:
CH 4075 – Pharmaceutical Law and Ethics
Credit Value:
2C
Rationale:
This course will give a broad knowledge about the pharmaceutical law within the country, regulation of cosmetics, devices and drugs and controlled substances. The role of a pharmacist and the requirements needed to practice as a pharmacist are taught in this course which will be beneficial for the student to practice as a pharmacist. This course will provide a range of employment areas in the pharmaceutical industry.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- explain the role of the pharmacist.
- explain the significance of pharmacy law.
- identify the acts relevant to pharmacy.
- describe the code of ethics.
- explain the laws involved in prescribing, supplying and administering drugs.
- explain the regulations for cosmetics, devices and drugs.
- explain the steps involved in registering a drug.
- explain laws regarding controlled substances.
- explain the laws involved in prescribing, supplying and administering controlled substances.
- explain how controlled substances are stored in a pharmacy.

Course Content:
Pharmaceutical law; National Law: Medicinal Ordinance – Registration of Pharmacists, Poisons, Opium and Dangerous Drugs Ordinance, Cosmetics, Devices and Drugs Act 1980, Regulations and their Amendments, Food Act, Excise Act, Fair Trading Commission and the Pricing of Pharmaceuticals (consumer protection Act); International Law: Convention on narcotic drugs, Convention of psychotropic drugs, Other legislation affecting the practice of pharmacy; Miscellaneous Legislation: e.g. Health and Safety Legislation, Consumer Protection Laws Acts on Trade; An awareness of the regional legislation, their relationship to national legislation. Concept of a Profession and their Regulatory Councils, Professional responsibilities: standards of conduct and practice including the "code of ethic" of the profession; World Health Organization Criteria of Ethical Drug Promotion, Sri Lanka Medical Association (SLMA) Ethical criteria for the Promotion of Medicinal Drugs and Devices in Sri Lanka, International Federation of Pharmaceutical Manufacturers Association (IFPMA) Code, Code of Conduct for Medical Representatives put out by the Sri Lanka Chamber of

Pharmaceutical Industry; SLMA Declaration on Health, Alma ATA Declaration (WHO), Health for All Vision of the WHO.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Cosmetics, devices and drugs Act and regulation thereof, Poison, Opium and dangerous drugs ordinance, Medical ordinance, Medical ethics and practice-A guide for pharmacist –Royal pharmaceutical society of Great Britain.

Course Code and Title:
CH 4076 – Pharmaceutical Management and Administration
Credit Value:
3C
Rationale:
Pharmaceutical management and administration focuses on the corporate and managerial aspects in the pharmacy profession. This course will equip students with skills required to successfully manage and administrate pharmacy related sectors. This will provide professionalism to the students to work as managers or administrators in the health care system.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- define the concept of management.
- describe the role of a manager.
- describe the principals involved in successfully managing employees.
- explain inventory control procedures and how to successfully manage them.
- describe strategies to improve patient care.
- explain the drug procurement process.
- describe basic accounting principles.
- describe payment and pricing policies.

Course Content:
The administration and organization of drug supply and pharmacy services in State sector and private pharmacies. Principles of storage: Refrigerated Cold chain monitors; Policy and legal framework; Drug management cycle viz., Selection, Procurement, Distribution, Use; Management support systems viz., Organization and Management, Financing and sustainability, Information Management Human Resources Management; Basic principles of industrial and business management; Basic accounts, financial and cost accountancy as related to pharmaceutical trade, industry and trial pharmacies, import and export procedures; Basic aspects of marketing and advertising with special reference to the pharmaceutical trade; Pharmaceutical Manufacturing and Local Pharmaceutical Industry.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Managing drug supplies-World health organization, Manual of management of drugs – Ministry of health, Sri Lanka.

Course Code and Title:
CH 4077 – Pharmacy Practice
Credit Value:
2C
Rationale:
This practical course will equip the students with hands on experience in analysis of different dosage forms and formulation of different dosage forms. This course will also provide the students with the knowledge of patient centered care, manage patient health care needs. These skills will be beneficial for the students to work in a range of employment areas and provide opportunities to work in the pharmaceutical industry and the health care system.
Pre-requisites:
CH 3075 Practical Pharmacy
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- evaluate patient orders of patients.
- dispense drug products according to legal requirements.
- select proper packaging for different drug products.
- evaluate physicochemical properties of raw materials as well as various dosage forms.
- analyze active ingredient content in different dosage forms.
- identify problems, explore potential strategies in designing, implementing and evaluating viable solutions.

Course Content:
Pharmaceutics, Pharmaceutical chemistry, Pharmaceutical Analysis and clinical pharmacy.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(ii) Practical pharmaceutical chemistry part 1 and part 2 (Backett and Stenlake)
(iii) Jenkins' Quantitative pharmaceutical chemistry (Knevil and Digangi)
(iv) Pharmaceutical chemistry volume 2 (drug analysis) (Roth, Eager and Troschutz)
(v) The British Pharmacopoeia, The United States Pharmacopoeia
(vi) Handouts issued in the laboratory.

Course Code and Title:
CH 4078 – Pharmacognosy in pharmacy
Credit Value:
2C
Rationale:
This course focuses on potential drugs or drug substances from natural origin. Pharmacognosy in pharmacy will provide the students the knowledge of chemical, biochemical and biological properties of drugs derived from natural sources. The course will equip the students with the skills to work as a natural product scientist in the pharmaceutical industry.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- discuss the history of drugs discovered from natural sources.
- explain how medicinal compounds are extracted from natural sources.
- explain how natural products are screened to identify potential drug compounds.
- to explain what a lead compound is.
- discuss how a lead compound contributes to the design of new more effective and safe drugs.
- explain the importance of biotechnology in industrial production of natural drugs.

Course Content:
Introduction to and brief history of pharmacognosy; herbal systems of medicine. Pharmaceuticals, cosmeceuticals, and lead compounds of natural origin; crude preparations of natural product extracts as drugs; isolation, characterisation, and screening of natural products. Classification by biosynthetic pathway, chemical structure, and condition treated; major drugs from carbohydrates & glycosides, lipids, terpenoids, steroids, phenylpropanoids, polyketides, alkaloids, peptides, and miscellaneous antibiotics; Pharmaceutical biotechnology; plant breeding and tissue culture, genetic modification of organisms, industrial production of natural products by cell culture. Case studies (Taxol, Penicillin).
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Textbook of Pharmacognosy (Trease and Evans)
(ii) Textbook of Pharmacognosy and Pharmacobiotechnology (J.E. Robbers, M.K. Speedie & V.E. Tyler)
(iii) Drugs of Natural Origin (G. Samuelsson).

Course Code and Title:
CH 4090 – Advanced Molecular Modeling
Credit Value:
1C
Rationale:
This course is designed to provide an in depth knowledge on theoretical methods using molecular modeling.
Pre-requisites:
CH 3006
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- apply advanced molecular modeling techniques to solve molecular level research problems.

Course Content:
Energy minimization: steepest descent method, conjugate gradient method; and related methods for exploring the potential energy surfaces, non-derivative minimization methods, derivative minimization methods, first order and second order minimization methods, selection of suitable minimization methods, calculation of thermodynamic properties using molecular dynamics (Monte Carlo & molecular dynamics) simulation methods. Molecular dynamics beyond micro-canonical ensemble. Hydrophobic interaction, Introduction to Kirkwood-Buff theory of solvent mixtures.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Molecular modeling (A.R. Leach).

Course Code and Title:

CH 4901 -Bioanalytical Chemistry II

Credit value:

2C

Rationale:

This course unit is designed to provide advanced knowledge of various bioanalytical methods.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- use advanced analytical methods for bioanalysis.
- use apropreateanalytical method for the analysis of biomolecules.
- validate analytical methods used in bioanalysis.

Course Content:

Development and validation of bioanalytical methods, LOD, LOQ, accuracy, precision, trueness, and biasness, basics of electroanalytical methods, Ion selective electrodes and electrochemical biosensors, electrochemical methods for bioanalysis, mass spectrometry, principle of mass spectrometry, MALDI, TOF, ESI, MS×MS methods for bioanalysis, Bioanalysis using magnetic resonance spectroscopy, principles of nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) technologies, NMR and MRI methods for bioanalysis,lab-on-chip point of care devices for bioanalysis, portable tools and other recent developments in bioanalysis, laboratory data management and report preparations.

Method/s of Evaluation:

End of semester examination (70%) and continuous Method/s of Evaluations (up to 30%)

Recommended Readings:

(ii) BioanalyticalChemistry (A. Manz, P. Dittrich, N. Pamme, D. Iossifidis)

(iii) Bioanalytical Chemistry; S. Mikkelsen, E. Corton)

(iv) Fundamentals of analytical chemistry (D. Skoog, D. M. West, F. Holler)

(v) Principles of instrumental analysis (D. Skoog, F. Holler, S. Crouch).

Course Code and Title:
BC 3021-Food Chemistry
Credit Value:
2C
Rationale:
This course aims to provide in-depth knowledge of basic scientific principles of food systems and their applications, chemical/biochemical reactions of components such as carbohydrates, lipids, proteins, and other constituents and processes that affect color, flavor, texture, nutrition, and safety of food.
Pre-requisites:
BC 1008
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- outline the major and minor constituents in food.
- identify factors that cause changes in food components.
- discuss the occurrence and structural properties of sugar and starch.
- explain applications of food gums in food industries.
- outline the classification and properties of fatty acids based on their structures.
- explain the effects of food lipids on human health.
- explain the role of antioxidants in food preservation.
- classify proteins into different groups and outline how their structure affects their functional properties.
- list ways in which proteins in food can be denatured.
- identify flavour compounds and pigments used in foods.
- explain structural properties of chlorophyll, anthocyanins, carotenoids and curcumins
- explain structural properties of micronutrients.
- list the types and role of food additives in food industries.
- list methods used in analyzing major and minor components in foods and food additives.

Course Content:
Introduction to food components: Major and minor constituents in food, Water, Interaction of food components, Factors that cause changes in food components; Food carbohydrates: Classification; Sugars and their derivatives: Occurrence in food, Structure and properties of glucose, lactose, maltose and sucrose; Oligosaccharides: raffinose and stachyose; Starch: Occurrence in food, Properties of amylose and amylopectin, Gelatinization of starch; Cellulose and hemicelluloses; Pectins: Occurrence in fruits and vegetables, Physico-chemical properties, Application in food industry; Food gums and their application in food industry; Methods used in the determination of carbohydrates; Food lipids: Classification of lipids, Properties of fatty acids, Triglycerides and polar lipids; Fats and oils: Rancidity, Autoxidation of fats, Mechanism of action of antioxidants, Refining and modification of fats, Effects of food

lipids on health, Analysis of fats and oils; Proteins: Factors that cause denaturation of proteins, Enzymes, Meat protein, Milk proteins, Egg protein, Wheat protein, Methods used in the determination of proteins in food, Interaction of proteins with other food components; flavour compounds and pigments in food: Occurrence of natural flavour impact compounds in food, Methods used in flavour analysis, Development of flavour during cooking and processing, Structure and properties of chlorophyll, Anthocyanins, Carotenoids and curcumins; Micronutrients: Structure and properties of vitamins and minerals in food, Methods of analysis; Food Additives: Preservatives, Antioxidants, Artificial food colours and flavours, Natural and synthetic emulsifiers and stabilizers, Safety of food additives, Methods used in analysis of food additives

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Food, The Chemistry of its Components (T.P. Coultate)
(ii) Integrated Food Science and Technology for the Tropics (A.I. Ihekoronye & P. O. Ngoddy)
(iii) Nutritional Biochemistry (S. Ramakrishnan & S. Venkat Rao)
(iv) An Introduction to the Chemistry and Biochemistry of Fatty Acids and their Glycerides (F. D. Gunstone)
(v) Polysaccharides in Foods (J. M.V. Blanshard & J. R. Mitchell).

Course Code and Title:

BC 3022 - Metabolism 1

Credit Value:

2C

Rationale:

This course is designed to provide a broad knowledge on the pathways of intermediary metabolism by which cells degrade carbohydrates to provide energy required by changing the chemistry of molecules in biochemical steps through regulating by effector molecules and hormones in living systems.

Pre-requisites:

CH 2013

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- recognize how thermodynamics, electrochemistry and chemical equilibrium used in achieving biochemical reactions in metabolic pathways.
- explain how metabolic pathways (glucose, polysaccharides and fatty acid**)** are used in the generation and storage of energy.
- recognize different cycles/ pathways operates in above mentioned metabolic pathways.
- compare the effects of various disease states on the alteration of above mentioned metabolic pathways.

Course Content:

Introduction: overview of metabolism; energetics of biochemical reactions, redox reactions, hydrolysis of "high energy" molecules, ATP; determination of biochemical pathways, labelling studies., Metabolism of glucose: glycolysis, citric acid cycle, electron transport, photosynthesis, pentose phosphate pathway, gluconeogenesis, regulation of glucose metabolism. Metabolism of polysaccharides: structure and biosynthesis of glycogen and starch, cellulose, chitin, hyaluronic acid, glycoproteins; catabolism of glycogen; regulation of carbohydrate metabolism. Fatty acid metabolism: lipid digestion and transport; beta oxidation; fatty acid biosynthesis; Ketone body synthesis and utilization, regulation of lipid metabolism. Metabolic disorders: Disorders of carbohydrate metabolism (glycogen storage disease, diabetes), Disorders of fatty acid oxidation and mitochondrial metabolism (Medium-chain acyl-coenzyme a dehydrogenase deficiency, MCADD).

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Biochemistry (C. K. Mathews & K. F. van Holde) (ii) Biochemistry (D. Voet & J.G. Voet).

Course Code and Title:

BC3023 - Metabolism II

Credit Value:

2C

Rationale:
This course is designed to provide a broad knowledge on the pathways of intermediary metabolism by which cells degrade lipids (fats), and nitrogenous compounds to provide energy required by changing the chemistry of molecules in biochemical steps through regulating by effector molecules and hormones in living systems and how several human diseases arise from defects in these pathways.
Pre-requisites:

BC 3022

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- describe how amino acid metabolic pathways are used in the generation and storage of energy.
- recognize different cycles/ pathways operates in metabolic pathways (Amino acid, nucleotide, heme).
- describe the effect of fed vs fasting states on metabolic pathways.
- compare and contrast tissue-specific metabolism.
- explain the effects of various disease states on the alteration of metabolic pathways.

Course Content:

Nitrogen metabolism: nitrogen cycle, nitrification, and nitrogen fixation; transamination and the role of glutamate; urea cycle. Amino-acid metabolism: overview and the central role of the citric acid cycle; catabolism of individual amino-acids; anabolism of individual amino-acids, regulation of amino acid metabolism. Compounds derived from amino-acids: porphyrins; bioactive amines; tetrahydrofolate; alkaloids (overview only). Nucleotide metabolism): biosynthesis of purines and pyrimidines and their ribonucleotides; deoxyribonucleotides; nucleotide coenzymes; catabolism of nucleotides. Heme metabolism: Heme Synthesis, Regulation of heme synthesis, Porphyrias, Heme degradation, Hyperbilirubinemia (jaundice).Regulation and integration of mammalian metabolism: Tissue specific metabolism: liver, brain, muscle, kidney and heart. Metabolism in well-fed and fasting state and during starvation. Metabolic disorders: Disorders of amino acid metabolism (phenylketonuria, maple syrup urine disease, glutaric acidemia type 1), Urea Cycle Disorder or Urea Cycle Defects (Carbamoyl phosphate synthetase I deficiency), Disorders of organic acid metabolism [organic acidurias., alcaptonuria], Disorders of porphyrin metabolism (acute intermittent porphyria), Disorders of purine or pyrimidine metabolism (Lesch-Nyhan syndrome).

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Biochemistry (C. K. Mathews & K. F. van Holde) (ii) Biochemistry (D. Voet & J.G. Voet).

Course Code and Title:

BC 3024 – Bio-Physical Chemistry

Credit Value:

2C

Rationale:

This course enables students to apply concepts in thermodynamics, spectroscopy, electrochemistry and concepts in radioactivity pertaining to biological systems. Students will be able to synthesize these concepts so that they can be applied in relation to biological and clinical instances.

Pre-requisites:

CH 2012, CH 2013

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- apply the concepts in thermodynamics to biological systems.
- apply thermodynamics to membrane equilibria and chemical equilibria involving macromolecules.
- explain and analyze transport processes in biological systems.
- distinguish the importance of methods for separation and characterization of macromolecules.
- identify the applications of spectroscopy in the analysis of biochemical systems.
- identify the basic concepts in radiochemistry and its applications in biochemistry.
- solve quantitative or conceptual problems in thermodynamic applications, spectroscopic methods, derive equations, and use graphical methods.

Course Content:

Thermodynamics: Review of first and second laws of thermodynamics in relation to biological systems, Work and Gibbs energy change, Multi-component systems and Partial molar properties, Phase equilibria, Application of chemical potential to physical equilibria: membrane equilibria, osmotic pressure; Transport across membranes: passive, active and facilitated transport. Methods for the separation and characterization of macromolecules: General principles, Sedimentation: determining sedimentation coefficient – moving boundary sedimentation and sedimentation equilibrium, Analytical ultracentrifuge; Membrane separations: microfiltration, ultrafiltration, reverse osmosis; Electrophoresis and Isoelectric focusing, Mass spectrometry, X-ray diffraction, Surface imaging techniques, Atomic absorption microscopy. Chemical equilibria involving macromolecules: Review of thermodynamics of chemical reactions in solution; Interactions between macromolecules:

association and dissociation, binding of small ligands by macromolecules; Characterization of macromolecular binding processes by SPR bio sensing, Spectroscopy: Review of electronic absorption spectroscopy; Applications of UV/visible spectroscopy to proteins and nucleic acids; Theory and applications of circular dichroism; Theory and applications of fluorescence. Radioactivity: Radioactive emissions and decays; Units of radioactivity; Radiation dose; Radiation detection and measurement; Radioisotopes in research.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Principles of Physical Biochemistry (K. E. van Holde, W. C. Johnson, & P. S. Ho) (ii) Biochemical Calculations (I. H. Segel).

Course Code and Title:

BC 3025-Protein Structure and Function

Credit Value:

2C

Rationale:

The course aims to provide in-depth knowledge on protein structures, how they are constructed, how they work and how they are stabilized and their dynamics, thermodynamics, stability and folding in biological environment.

Pre-requisites:

CH 2013

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- relate the properties of metal ions to their functions in biological systems.
- apply the principles of coordination chemistry to biological systems.
- explain and analyze transport processes in biological systems.
- differentiate and describe different structural stages and their importance of a given protein.
- apply their knowledge on protein structure to explain the function of selected proteins.
- explain protein folding and denaturation processes.
- explain few diseases caused due to misfolding of proteins.

Course Content:

Review of the Primary structure of proteins: AAs, peptides structure and conformation, Ramachandran plots. Secondary structure of proteins: Helices, β-structures, Turns, Fibrous proteins (α-keratin). Tertiary structure of proteins: Globular proteins, Domains, Super secondary structures/motifs. Quaternary structure of proteins: Subunits and importance of having multiple subunits. Structure and function of hemoglobin and myoglobin, cooperative effect, Bohr effect, sickle cell anemia; Electron transfer proteins (cytochromes and iron sulfur proteins), structure and function; zinc metalloproteins, properties of zinc in zinc metalloproteins, structural and functional role of zinc, zinc fingers, superoxide dismutase, carbonic anhydrase and carboxypeptidase A. Protein stability: Review of the important chemical interactions (Electrostatic interactions, Ionic interactions, Dipole-dipole interactions, Hydrogen bonding, Hydrophobic forces, Disulfide bonds). Protein denaturation. Protein folding: Determinants of protein folding, Protein folding pathways, Folding accessory proteins. Protein dynamics (basic introduction), Conformational diseases.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(ii) Biochemistry (A.L. Lehninger)
(iii) Biochemistry (C.K. Mathews, K.F. Van Holde)
(iv) The principles of bioinorganic chemistry (S. J. Lippard, J. M. Berg)
(v) The biological chemistry of the elements: The inorganic chemistry of life (J. J. R. F. da Silva, R. J. P. Williams)
(vi) Biochemistry (D. Voet, J.G. Voet).

Course Code and Title:

BC 3026-Laboratory Techniques in Biochemistry and Molecular Biology

Credit value:

4C

Rationale:

This course provides proficiency in designing and conducting experiments involving genetic manipulation of prokaryotes and eukaryotes, identification of disease conditions based on biochemical constituents appeared in biological fluids.

Pre-requisites:

CH 2013

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- prepare basic molecular biology and biochemical reagents.
- isolate DNA and RNA from plants and animal tissues.
- clone DNA using plasmid vectors.
- set up reactions to digest genomic DNA with restriction enzymes.
- set up and carry out techniques such as Northern and Southern blotting.
- design a nucleic acid hybridization assay.
- design a PCR assay to amplify DNA.
- reverse transcribe RNA.
- titer and Screen a genomic/cDNA library.
- recognize the role of clinical biochemistry in clinical diagnosis.
- set up biochemical assays to detect normal and abnormal constituents in urine.
- be proficient to handle equipment used in clinical biochemistry.
- be proficient in the interpretation of results of routine clinical biochemistry investigations.
- to develop problem-solving skills relevant to the practice of clinical biochemistry.

Course Content:

Isolation of DNA & RNA from animal and plant tissues, Northern blotting, Synthesis of cDNA by reverse transcription, RT-PCR; DNA labeling, DNA hybridization and hybrid detection; Construction of genomic and cDNA libraries in plasmids and lambda phage. Screening of phage libraries, Isolation of recombinants and in-vivo excision; DNA sequencing and sequence analysis; Yeasts transformation, Gene complementation in yeasts; Plant transformation, Cell culture and transfection; Expression of recombinant proteins; Western blotting and ELISA. Determination of chloride, Calcium ions in blood serum, Determination of estrogen levels in chicken, Determination of serum Na^+, K^+, Mg^{2+} and Ca^{2+} levels using atomic absorbtion spectrophotometery, Lipid profiles, Determination of total protein in blood, SDS-PAGE (Sodium dodecyl sulfate-Polyacrylamide gel electrophoresis), Aspartate transaminases, Creatine kinase assays, Analysis of abnormal constituents in urine, Blood glucose and glycosylated hemoglobin analyses.

Method/s of Evaluation:

End of semester practical examination

Recommended Readings:

(i) Molecular Cloning: A Laboratory Manual (J. Sambrook, E.F. Fritsch & T. Maniatis)

(ii) Principles of Fermentation Technology (P F Stanbury and A Whitaker)

(iii) Biochemical Techniques: Theory & Practice (John F. Robyt and Bernard J. White).

Course Code and Title

BC 3027: Enzymology

Credit value:

2C

Rationale:

This course brings together structural and kinetic information to understand different mechanistic models of enzyme catalysis and discusses the industrial applications of enzymes.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- recognize the basic reaction classification of various enzymes.
- recognize the type of catalysis for each of the enzymes studied.
- apply the kinetics and thermodynamics for an enzymatic catalyzed reaction.
- explain mode of action of enzymes in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity.
- explain the role the amino acids in the catalytic site play in the reactions.
- realize how an X-ray crystal structure is used to determine the active site of an enzyme.

Course Content:

General properties of enzymes; Enzyme nomenclature, Substrate specificity, Cofactors and coenzymes, Catalysis mechanisms; Acid-base catalysis, Covalent catalysis, Metal ion catalysis, Electrostatic catalysis, Catalysis through proximity and orientation effects, Catalysis by preferential transition state binding, Active site residues of different enzymes and positioning, Substrate kinetics, Kinetics of enzyme inhibition, Substrate inhibition, Nonproductive binding, Competing substrate, Multi-substrate system, Allosterism and cooperativity, Primary and secondary isotope effects on enzyme catalyzed reactions, Study of the mechanisms for selected enzyme catalysis reactions: Structure-activity studies, Structure based inhibitor design, Introduction to combinatorial chemistry.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) The Organic Chemistry of Enzyme Catalyzed Reactions (R. B. Silverman).

Course Code and Title:

BC 3030 - Practical Biochemistry and Molecular Biology

Credit Value:

8C

Rationale:

This course provides proficiency in designing and conducting experiments involving genetic manipulation of prokaryotes and eukaryotes and the diagnosis of disease conditions based on biochemical constituents appeared in biological fluids. Practical conducted in the areas of Techniques in Recombinant DNA Technology and General Biochemistry, Plant Molecular Biology and Clinical Biochemistry.

Pre-requisites:

CH 2013, MB 3025

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- analyze the results of biochemical tests performed on urine & blood analysis.
- recognize the mechanism of enzyme catalyzed reactions.
- design the strategies to set up fermenter and to analyze fermentation products.
- assemble the set up for paper chromatography, gel electrophoresis (horizontal and vertical) and blotting for isolated biological molecules.
- separate and appraise the isolated biological molecules.
- design the DNA cloning, gene expression, protein separation and purification, DNA labelling, PCR, ELIZA experimental set ups.
- design the *Agrobacterium* mediated transformation of plant cells.
- analyze transgenic tissues using GUS assay.

Course Content:

Buffer preparation, Quantitative analysis of amino acids using titration, Purification of α –amylase from saliva, quantification, activity determination of α –amylase, Study of effect of enzyme and substrate concentration on rate of the reaction, Study of effect of time & temperature on rate of the reaction, Extraction of protein content in red lentils *Lens culinaris* analysis using TLC, Determination of blood glucose by colorimetric methods, Estimation of plasma creatine by Jaffe reaction, Analysis of Urine, Isolation & characterization of erythrocyte membranes, Thin layer chromatography for lipids extracted from erythrocyte membranes, Assessment of antioxidant activity of plant extracts, enzyme kinetics, Determination of total protein in blood, SDS-PAGE (Sodium dodecyl sulfate-Polyacrylamide gel electrophoresis), Aspartate transaminases, Creatine kinase assays, His-tag protein purification, Genomic & plamid DNA isolation from bacteria, animal & plant cells, gel electrophoresis.Introduction of DNA into cell; DNA cloning, restriction mapping; screening of recombinant clones; DNA labeling, Southern hybridization, Northern blotting, PCR. Construction of genomic and cDNA libraries in plasmids and lambda phage. Screening of phage libraries. Yeasts transformation, Gene complementation in yeasts; *Agrobacterium* mediated transformation of plant cells, Cell culture and transfection; Expression of recombinant proteins; Western blotting and ELISA Synthesis of cDNA by reverse transcription, RT-PCR.

Method/s of Evaluation:

End of semester practical examination

Recommended Readings:

(ii) Molecular Cloning: A Laboratory Manual (J. Sambrook, E.F. Fritsch& T. Maniatis)
(iii) Biochemical Techniques: Theory & Practice (John F. Robyt and Bernard J. White)
(iv) Handouts issued in the laboratory.

Course Code and Title:

BC 4001 – Research Project

Credit Value:

8C

Rationale:

This course is designed to provide the opportunity for students to plan and execute a research project independently.

Intended Learning Outcomes:

Upon completion of this course students will be able to:

- carry out a comprehensive literature search under a given research problem.
- design and implement a suitable experimental / theoretical procedure.
- critically analyze any data generated.
- write a comprehensive account of the literature survey, experimental procedure and analysis of results, and discussion.
- effectively communicate any findings and defend the work in a professional manner.

Method/s of Evaluation:

End of year evaluation of thesis and *viva voce*

Course Code and Title:

BC 4002 – Seminar and Essay

Credit Value:

3C

Rationale:

This course is designed to provide the opportunity for students to improve their comprehension and writing skills.

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- read and understand scientific publications.
- critically and carefully analyze the information.
- extract the core essence.
- present the information in a comprehensive and interesting manner to a large and diverse audience.
- effectively answer questions asked.
- explain / answer questions using the knowledge gathered during the programme.
- be up-to-date on current developments in the field of biochemistry / molecular biology.
- write a comprehensive account, elaborating on a current topic in biochemistry / molecular biology.

Method/s of Evaluation:

Seminar**-** End of the semester evaluation

Essay - End of year evaluation

Course Code and Title:
BC 4003 – General Paper
Credit Value:
3C
Rationale:

This course is designed to test the application of basic knowledge in all fields of biochemistry/ molecular biology.
Pre-requisites:

None

Intended Learning Outcomes:
Upon completion of this course students should be able to:

- apply the basic principles in problem solving in the areas of biochemistry / molecular biology.

Method/s of Evaluation:
End of year examination

Course Code and Title:

BC 4005 - Advanced Topics in Biochemistry and Molecular Biology

Credit Value:

2C

Rationale:

The course is designed to provide an in-depth knowledge of some important topics in Biochemistry and Molecular Biology.

Pre-requisites:

BC 3025, MB 3022

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- describe the different types of intercellular signaling.
- describe the different classes of cell surface receptors.
- describe the components of signal transduction pathways.
- explain the roles of GTPase switch proteins in signal transduction.
- describe the role of G proteins in disease.
- compare the structures of different Receptor tyrosine kinases (RTKs).
- explain the mechanism of action of lipophilic hormones.
- explain the basic principles of Gene therapy.
- distinguish between classical and non-classical gene therapy.
- differentiate between Ex-vivo and In-vivo gene therapy.
- compare the different vectors used in gene therapy.
- design an antisense oligonucleotide.
- distinguish between antigene and antisense strategies.
- describe the common features of cancer.
- explain how proto-oncogenes are converted to oncogenes.
- explain the role of retinoblastoma protein and p53 in cancer.
- identify factors affecting protein structure & determination of protein structure using bioinformatics tools.
- appraise the changes to be introduced to improve stability/reactivity of protein.
- design an experiment to obtain a protein with improved stability/reactivity.
- recognize random & *in vitro* mutagenesis strategies.

Course Content:

Cell signaling and signal transduction: Systems of extracellular communication. Types of intercellular signaling, Signaling molecules. Components of signal transduction pathways. Classes of cell surface receptors, G-protein coupled receptors, GTPase switch proteins, adapter proteins, protein kinases. 2nd messengers. Effectors: Adenylyl cyclase, Phospholipases. Inositol triphosphate (IP3) and control of intracellular cellular Ca^{2+} levels. Structure function and activation of protein kinase C. Role of G-proteins in diseases. Receptor tyrosine kinases, activation of Ras. Signaling pathways initiated by insulin. Down regulation of receptors. Mechanism of action of lipophilic hormones. Gene therapy**:** Principles of gene therapy. Classical gene therapy & non classical gene therapy. Ex-vivo gene therapy In-vivo gene therapy, Principles of gene transfer, Routes of delivery. Methods of gene transfer. Viral delivery systems: Adenoviruses, retroviruses, lentiviruses etc. Packaging cell lines. Non viral delivery systems: Naked DNA (Plasmids), Designing Plasmids, methods of delivery. Oligonucleotides: Antisense and antigene strategies. Designing antisense oligonucleotides, targeted inhibition of gene expression and Ribozymes. Antigene strategies: Aptamers, siRNA. Non viral vectors : Polymeric and liposomal delivery systems, Cationic, anionic and specialized liposomes. Polymeric delivery systems: Polyethyleneimine, Polylysine, chitosan and dendrimers. Current trends in gene therapy. Cancer**:** Common features and causes of cancer. Classification of cancers. Cancer development /carcinogenesis. Initiation, progression and invasion. Clonal origins of cancer. Treatment and prevention. Molecular genetics of cancer. Oncogenes: Discovery, origin of viral oncogenes. Proto-oncogenes and their functions. Conversion of proto-oncogenes to oncogenes. Oncogene model of carcinogenesis. Tumor suppressor genes and their functions. Repressor proteins and their inactivation. Retinoblastoma protein. Tumor suppressor p53, its structure, function and regulation and its role in cancer. Protein engineering**:** Bioinformatics in protein structure and function prediction, Strategies of protein engineering, random and *in-vitro* mutagenesis in protein engineering, Tailoring protein properties and function (Insulin, T4 lysozyme, serine proteases etc.), Analysis and applications of altered proteins.

Method/s of Evaluation:

End of the semester examination

Recommended Readings:

(i) Molecular Cell Biology (H. Lodish, A. Berk, P. Matsudaira, C.A. Caiser, M. Krieger, M.P. Scott, S.L. Zipursky, J. Darnell)
(ii) Human Molecular Genetics (S. Strachan ,P. Andrew, A.P. Read).

Course Code and Title:

BC 4006 - Selected Topics in Biochemistry and Molecular Biology

Credit Value;

2C

Rationale:

This course aims to provide comprehensive introduction to designing and operation of molecular diagnostic laboratories and methods used in these laboratories in detecting genetic materials and defects, alteration etc. associated with them, with regards infectious diseases, blood disorders, genetic diseases, cancer etc. The fermentation processes used in the production of useful microbial biochemicals are also provided.

Pre-requisites:

BC 3025, MB 3025

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain how to design and organize a molecular diagnostic laboratory.
- describe the standard operating procedures for sample processing and quality assurance for molecular diagnostics.
- describe the application of molecular Biology techniques in the diagnosis of infectious diseases, blood disorders, diagnostic oncology, and identity testing.
- describe the use of molecular therapeutics and recombinant proteins in medical practice.
- understand the advances made in human gene therapy trials.
- describe the applications of Cytogenetics and Hybridoma technology in medicine.
- explain growth and growth kinetics in a batch culture and continuous culture.
- describe methods of measuring growth of microbial cultures.
- explain biochemical meanings of respiration and fermentation.
- explain different types of fermentation processes.
- describe main metabolic pathways present in microbes.
- explain the parts of fermenter along with function of those parts.
- describe different types of fermenters.
- describe fermentation processes leading to production of useful microbial biochemicals; Alcohol for biofuel, Acetone & butanol, Glutamic acid, citric acid.
- the fermentation processes leading to production of various microbial biochemical.

Course Content:

Molecular Diagnostics and Therapeutics: Design a laboratory for molecular diagnosis-Basic principles, Aspects on sample processing and quality assurance, Applications in infectious diseases- part I, Applications in infectious diseases- part II, Applications in blood disorders, Applications in diagnostic oncology, Applications in identity testing, Molecular therapeutics used in medicine, Advanced in human gene therapy trials, Uses of recombinant proteins medical practice, Cytogenetics- analysis of human genetic disorders I, Cytogenetics- analysis of human genetic disorders II, Hybridoma technology – application in medicine. Fermentation Technology: Microbial growth and growth kinetics; batch culture, continuous culture (Chemostat and turbidostat) and fed-batch culture systems, Biochemical meaning of fermentation and respiration, Microbial metabolites: Primary and Secondary, Classification of fermentation processes 1 microbial cells (biomass) production, 2) production of microbial enzymes, 3) production of microbial metabolites, 4) modification of compounds,– transformation process, Different metabolic path ways in microorganisms, Media for industrial fermentation: Types of media:, Media formulation, Constituents used in media, Fermentation Equipment: Points to be considered when designing a fermenter, Three main types of fermenters: Stirred, baffled and aerated tank type, The component parts of a fermenter and their functions, Industrial production of Glutamic acid, Acetonol –Butanol fermentation, Alcohol fermentation, citric acid fermentation.

Method/s of Evaluation:

End of the semester examination

Recommended Readings:

(i) Molecular Diagnostics (William B Coleman & Gregory J Tsongalis)
(ii) Principles of Fermentation Technology (P. F. Stanbury and A. Whitaker)
(iii) Bioprocess Engineering Basic concepts (Michael L. Shuler and FikretKargi).

Course Code and Title:

MB 3003- Introduction to Genomics and Proteomics

Credit value:

2C

Rationale:

This course aims to provide insight into multitude of methods and techniques used in genomics and proteomics analyses and their principles and theoretical aspects.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- compare different systems used in recombinant protein expressions.
- describe different chromatographic techniques used in protein purification.
- describe different techniques used in separation of proteomes.
- explain common workflows for the large-scale analysis of proteins.
- explain methods used in mass spectrometry in protein identification.
- compare different techniques used in protein sequencing.
- explain the applications of proteomic research.
- compare the organization of prokaryotic and eukaryotic genomes.
- describe the core aims of genome projects.
- compare the methods available for detection of SNPs.
- describe the benefits of the human genome project.
- explain the applications of genome research.

Course Content:

Proteomics: Overview of proteomics; Protein expression systems, Methods used in proteome analyses: Protein Purification strategies (Ion-exchange Chromatography, Affinity chromatography, Gel filtration, Hydrophobic interaction, hydroxyl apatite chromatography), Fast protein liquid chromatography, 2D Gel Electrophoresis, SDS-polyacrylamide gel electrophoresis, Isoelectric focusing, Spot identification, 2D gel data analysis, Differential in-gel electrophoresis (DIGE), Drawbacks and limitation of 2D gel electrophoresis, Applications of 2D-PAGE, Characterization and identification of proteome using mass spectrometry, MALDI (Matrix-assisted Laser Desorption/Ionization), nESI (nanoelectrospray ionization), (MALDI-TOF (time of flight), Tandem mass spectrometry (MS/MS), Surface enhanced laser desorption ionization (SELDI), Protein sequencing by Edman degradation. Current trends in proteomics. Genomics Overview; Prokaryotic and eukaryotic genome organization; Genome projects: core aims, mapping, markers, high throughput sequencing (Sangers dideoxy method and next generation sequencing). Ssequence analyses, (prediction of gene structure, promoter regions, open reading frames, etc); comparative genomics, single nucleotide polymorphism (SNPs) : Methods of detection; databases (genomes, expressed sequence tags (EST), sequence tags sequence (STS) etc); DNA microarrays and its applications, The human genome project. Applications of genome research. Current trends in genomics.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Discovering Genomics, Proteomics and Bioinformatics (A.M. Campbell & L.J. Heyer)

(ii) High Throughput Techniques in Post Genomic Era (R.S. Dassanayake & Y. I. N. Silva Gunawardena).

Course Code and Title:

MB 3022-Gene Expression and Regulation

Credit Value:

3C

Rationale:

This course provides in-depth knowledge of gene expression and regulation in prokaryotes and eukaryotes and involvement of these processes in growth and development.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- identify operon, and list its parts.
- explain how a regulator gene controls transcription of an operon.
- explain the regulation of the *trp* and *lac* operons.
- identify different levels at which gene expression in eukaryotes may be regulated.
- explain how DNA modifications, Chromatin remodeling etc., used in activation and repression of gene expression.
- identify sequence elements, activators and repressors factors in eukaryotes and describe how they alter gene expression.
- list the different types of posttranscriptional, translational, and posttranslational control of gene expression in eukaryotes.
- define epigenetic inheritance.

Course Content:

Gene structure; Prokaryotic and eukaryotic gene transcription; Transcription factors, activators and repressors, Mechanism of activation and repression; DNA modifications, Chromatin remodeling; Transcription of class I, II and III genes, Posttranscriptional modifications (capping, splicing and polyadenylation); Transcriptional regulation (Myc-Max system, Yeast GAL system), Posttranscriptional regulation, Regulatory RNAs, Regulation of gene expression in development, epigenetic inheritance.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Genes VIII (B. Lewin).

Course Code and Title:
MB 3023-Recombinant DNA Technology
Credit value:
2C
Rationale:
This course provides in-depth knowledge about the techniques used identification of genetic materials and its defects and alteration, and genetic manipulation and engineering plants and organisms.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- describe the different tools used in rDNA technology.
- compare the different techniques available for labelling DNA.
- compare the different strategies used for gene cloning.
- describe how genomic and cDNA libraries are constructed.
- design a PCR assay.
- explain how DNA is sequenced and analyzed.

Course Content:
Tools of Molecular Biology; Microorganisms, enzymes & vectors. Cloning; Techniques of cloning; Cutting & joining DNA molecules using enzymes, gene transferring methodologies, Gel Electrophoresis, Blotting techniques (Southern and Northern) DNA Labelling techniques, Nucleic acid Hybridization; Strategies for gene isolation, Construction and screening of genomic & cDNA libraries, DNA sequencing and analysis, Chromosome walking, PCR. DNA microarray. Expression of recombinant proteins. Recent advances in rDNA technology.
Method/s of Evaluation:
End of semester examination
Recommended Readings:
(i) Recombinant DNA (Watson *et al*) (ii) Understanding DNA & gene cloning (K. Drlica).

Course Code and Title:

MB 3024-Topics in Molecular Cell Biology

Credit Value:

2C

Rationale:

This course is introduced to provide an overview of different molecular and cellular events take place in living cells, discuss different strategies in viral infection, replication, bacterial conjugation, recombination and transformation.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain molecular and biochemical and mechanisms involved in cell cycle regulation, apoptosis and ageing.
- explain various levels of gene regulation and protein function including signal transduction and cell cycle control.
- describe cellular interaction, organelle and cellular targeting.
- discuss the various macromolecular components of cells and their functions.
- explain molecular events during animal and plant development.
- discuss different strategies in viral infection, replication and gene expression.
- explain bacterial conjugation, recombination and transformation.

Course Content:

Molecular and biochemical mechanisms involved in cell cycle regulation, apoptosis and ageing; protein processing and protein sorting; Molecular and cellular interaction: membrane transporters, introduction to signal transduction, molecular aspects of nuclear cytoplasmic transport; Organelle and cellular targeting: chloroplast, mitochondria, peroxisomes, ER and Golgi; Molecular developmental biology: molecular events during animal and plant development, molecular basis of cellular induction and cell differentiation, homeo box genes in development and sex determination; Viruses and sub viral agents: viral infection strategy, diversity of replication strategy, strategies for viral gene expression, sub viral agents; bacterial genetics: bacterial conjugation, recombination, transformation, bacteriophage genetics; specialized cells: cancer cells and pathogen infected cells.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Molecular Cell Biology (H Lodish, M P Scott, P Matsudaira & J Darnell).

Course Code and Title:

MB 3025-Recombinant DNA technology and applications

Credit Value:

3C

Rationale:

This course provides in-depth knowledge about the techniques used identification of genetic materials and its defects and alteration, and genetic manipulation and engineering plants and organisms.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- describe the different tools used in rDNA technology.
- compare the different techniques available for labelling DNA.
- compare the different strategies used for gene cloning.
- describe how genomic and cDNA libraries are constructed.
- design a PCR assay.
- explain how DNA is sequenced and analyzed.
- describe the different applications of rDNA technology.

Course Content:

Tools of Molecular Biology; Microorganisms, enzymes & vectors. Cloning; Techniques of cloning; Cutting & joining DNA molecules using enzymes, gene transferring methodologies, Gel Electrophoresis, Blotting techniques (Southern and Northern) DNA Labelling techniques, Nucleic acid Hybridization; Strategies for gene isolation, Construction and screening of genomic & cDNA libraries, DNA sequencing and analysis, Chromosome walking, PCR. DNA & protein microarray. Applications of recombinant DNA technology in Medicine, Agriculture and Industry, Recent advances in rDNA technology.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Recombinant DNA (Watson *et al*) (ii) Understanding DNA & gene cloning (K. Drlica).

Course Code and Title

MB 3901 - Molecular Cell Biology

Credit value:

2C

Rationale:

This course is introduced to provide an overview of different molecular and cellular events take place in living cells, discuss different strategies in viral infection, replication, bacterial conjugation, recombination and transformation.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain the structure functional relationship of genes.
- describe molecular aspects of nuclear cytoplasmic transport and cellular targeting.
- explain molecular events that take place during animal and plant development.
- describe the different cellular signal transduction pathways.
- describe cell cycle and its regulation.

Course Content:

Anatomy and function of a gene, mutations and genetic analysis to identify and study gene structure and gene function, molecular and cellular interactions, molecular aspects of nuclear cytoplasmic transport of RNA and proteins, organellar and cellular targeting; mitochondria, chloroplasts, peroxisomes, introduction to signal transduction, signaling molecules and cell surface receptors, intracellular signal transduction, protein processing and protein sorting, molecular developmental biology, molecular events during animal and plant development, molecular basis of cellular induction and cell differentiation, homeo box genes in development and sex determination, cell cycle and cell growth control, cell cycle control and check points in cell cycle regulation, cell birth, lineage and cell death.

Method/s of Evaluation:

End of semester examination (70%) and Continuous Method/s of Evaluation (up to 30%)

Recommended Readings:

(i) Molecular Cell Biology (Harvey Lodish., Arnold Berk., Paul Matsudaira., Chris A Kaiser., Monty Krieger., Matthew Scott., S Lawrence Zipursky., James Darnell).

Course Code and Title:
MB 3902 - Animal & Plant Biotechnology
Credit value:
2C
Rationale:
This course unit provides insights into applications in animal and plant biotechnology related to agriculture and animal farming industries.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- explain the different techniques and tools used in plant and animal biotechnology.
- explain the bio-safety and Ethical issues of plant and animal biotechnology.

Course Content:
Status of world food supply, origin of agriculture and plant breeding (conventional),plant biotechnology: Molecular breeding: molecular markers and their applications, linkage maps and gene mapping, DNA fingerprinting, genetic diversity, Marker Assisted Selection (MAS),developing transgenic plants, tools and techniques in genetic engineering, plant tissue culture and somatic cell genetics, applications in genetic engineering, plants as bioreactors, biotech applications in plant protection, molecular diagnostics, bio-pesticides and fertilizer, molecular pathology and pest management, crop science and production, molecular pharming, metabolic engineering, nanotechnologies for agricultural bio-products, animal biotechnology, developing transgenic animals, application of genetic engineering in animals, embryo genomics, epigenetics and animal health, animal cloning, state of the art and applications, enzyme technology – dairy industry applications, Nutrigenomics: personalized nutrition, genetically engineered foods and perception, status of biotech food worldwide, bio-safety and bioethics, economic and social impact of agricultural biotechnology, current trends in agricultural biotechnology.
Method/s of Evaluation:
End of semester theory examination
Recommended Readings:
(i) Molecular Biotechnology, Principles &applications of recombinant DNA (Bernard, R Glick., Jack, J. Pasternak)
(ii) Comprehensive Biotechnology (Murray, Moo-Young).

Course Code and Title

MB 3903-Nanobiotechnology

Credit value:

2C

Rationale:

This course unit is aimed at providing an introduction and overview of nanotechnology, and potential application of nanomaterials and devices in biotechnology.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain the wide range of applications and overview of nanotechnology and its interdisciplinary aspect.
- explain the principles governing the effect of size on material properties at the nanoscale, and perform quantitative analysis.
- describe the structures and properties of building blocks of biological systems and how governing forces such as hydrogen bonding, ionic interaction, van der Waals interaction, hydrophobic interactions help to assemble the basic building blocks to form nanostructures.
- describe the native bionanomachinery in living cells, how cells use these "soft machines" for generating energy, motion, synthesizing biomolecules, and how these principles can be applied to design new biomolecules and bio-nanodevices.
- demonstrate knowledge on nanomaterials such as carbon nanotubes (CNT), fullerenes, quantum dots, iron oxide nanoparticles, polymer-based nanostructures (dendrimers), gold nanostructures and protein-based nanostructures applied in nanobiotechnology.
- demonstrate knowledge on nanotechnology techniques (synthesis, fabrication, characterization) and acquire the ability to use them to solve problems in bioengineering, biomedicine and agricultural/environmental issues.
- correlate the impact of nanotechnology and nanoscience in a global, economic, environmental, and societal context.

Course Content:

Chemical structures of biological building blocks and their covalent and non-covalent interactions to assemble the basic building blocks to form nanostructures, natural hierarchical nanostructures such as bones, importance of periodic structures,(butterfly wings to learn importance of periodic structures in optical application),the basics of nanotechnology, important organic and inorganic nanomaterials applied in bio-nanotechnology, mechanism of crystal growth to understand how to control the growth and importance of capping agents, characterization techniques of nanomaterials TEM, SEM, AFM, STM, XRD, TGA and other relevant methods, application of nanomaterials in biotechnology, medicine and agriculture, elaboration of medical applications of nanobiotechnology, nanostructures in drug discovery, cancer research and tissue engineering, nanostructures for daily applications (nano-sized ingredients in cosmetics).

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Nanobiotechnology: Concepts, Applications and Perspective (Christof, M. Niemeyer., Chad, A. Mirkin)

(ii) Nanotechnology in Biology and Medicine: Methods, Devices and Applications (Tuan, Vo-Dinh)

(iii) Molecular Cell Biology (Harvey, Lodish., Arnold, Berk., Lawrence, Zipursky., Paul, Matsudaira., David, Baltimore., James, Darnell)

(iv) Generic Methodologies for Nanotechnology: Characterization in Nanoscale Science and Technology (R. M., Brydson., C. Hammond).

Course Code and Title:

MB 4001- Genomics and Proteomics

Credit Value:

3C

Rationale:

This course aims to provide insight into multitude of methods and techniques used in genomics and proteomics analyses and their principles and theoretical aspects.

Pre-requisites:

CH 2014

Intended Learning outcomes:

At the end of the lecture series the students should be able to:

- compare different systems used in recombinant protein expressions.
- describe different chromatographic techniques used in protein purification.
- describe different techniques used in separation of proteomes.
- analyze post-translational modifications and protein-protein interactions.
- explain common workflows for the large-scale analysis of proteins.
- explain methods used in mass spectrometry in protein identification.
- compare different techniques used in protein sequencing.
- explain the applications of proteomic research.
- compare the organization of prokaryotic and eukaryotic genomes.
- describe the core aims of genome projects.
- compare the methods available for detection of SNPs.
- describe the benefits of the human genome project.
- explain the applications of genome research.

Course Content:

Proteomics: Overview of proteomics; Protein expression systems (bacterial, yeast, insects, mammals and baculovirus etc.),Methods used in proteome analyses: Protein Purification strategies(Ion-exchange Chromatography, Affinity chromatography, Gel filtration, Hydrophobic interaction, hydroxyl apatite chromatography), Fast protein liquid chromatography, 2D Gel Electrophoresis, SDS-polyacrylamide gel electrophoresis, Isoelectric focusing, Spot identification, 2D gel data analysis, Differential in-gel electrophoresis (DIGE), Drawbacks and limitation of 2D gel electrophoresis, Applications of 2D-PAGE, Characterization and identification of proteome using mass spectrometry, MALDI (Matrix-assisted Laser Desorption/Ionization), nESI (nano electrospray ionization), (MALDI-TOF (time of flight), Tandem mass spectrometry (MS/MS), Surface enhanced laser desorption ionization (SELDI), Protein sequencing by Edman degradation and protein sequence analyses; Protein Arrays: Types of protein Arrays, Data analysis, Applications of protein microarrays; Organelle and cellular proteomics; Protein and Enzyme Assays; Current trends in proteomics. Genomics: Overview; Prokaryotic and eukaryotic genome organization; high throughput sequencing and sequence analyses, (prediction of gene structure, promoter regions, open reading frames, etc.); comparative genomics, single nucleotide polymorphism (SNPs); gene mapping; databases (genomes, expressed sequence tags (EST), sequence tags sequence (STS) etc.); DNA microarrays and its application, current trends in genomics.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Discovering Genomics, Proteomics and Bioinformatics (A.M. Campbell & L.J. Heyer)
(ii) High Throughput Techniques in Post Genomic Era (R.S. Dassanayake & Y. I. N. Silva Gunawardena).

Course Code and Title:

MB 4003-Molecular Evolution, Modeling & Computer Based Drug Design

Credit Value:

3C

Rationale:

This course aims to provide knowledge in theoretical basis of bioinformatics encompassing homology modeling, molecular evolution, molecular docking and simulation, and computer aided drug design (CADD) with hand-on experience of computational methods in CADD.

Pre-requisites:

BT 3053, BT 3067

Intended Learning Outcomes:

At the end of the lecture series the students should be able to:

- identify the theoretical basis behind bioinformatics.
- search databases accessible on the WWW for literature relating to molecular biology and biotechnology.
- manipulate DNA and protein sequences using stand-alone PC programs and programs available on the WWW.
- find homologues, analyze sequences, construct and interpret evolutionary trees.
- analyze protein sequences, identify proteins, and retrieve protein structures from databases. View and interpret these structures.
- model 3D structure of proteins and design drugs using computer based protocols.

Course Content:

Protein structure analyses and prediction: Open Reading Frame prediction, Protein secondary structure analysis and prediction, Signal sequences, Protein subcellular localization prediction, transmembrane regions predictions. Functional Proteomics: Methods for determination of protein structure, Molecular motifs, Recognition and binding, Evolution, Antigenic regions; Molecular Evolution: Positive evolution, Negative evolution, Diversifying selections, Neutral selections; Microarray analysis: Processing array images, Filtering, clustering, Gene regulation, Evaluating analysis; Protein tertiary structure modeling: Ab-initio methods, Threading, Comparative modelling approaches, Visualization approaches; Molecular modeling: Force field methods to refine energies of systems (Monte Carlo and molecular dynamics simulations, simulated annealing, energy minimization); Computational docking and drug designing.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Molecular Modelling (A. R. Leach)

(ii) High Throughput Techniques in Post Genomic Era (R.S. Dassanayake & Y.I.N. Silva Gunawardene)

(iii) Computer Simulation of Liquids (M.P. Allen & D.J. Tildsley)

(iv) Bioinformatics and Drug Discovery (R. S. Larson) (v) Web Resources.

Course Code and Title:

MB 4004- Application in Biotechnology

Credit Value:

3C

Rationale:

This course is introduced to describe, what are transgenic plants, animals and microbes and their applications, explain mechanisms in metabolic engineering and stem cell technology, and appraise methods of bioremediation.

Pre-requisites:

BC 3025

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- describe different strategies use in microbial biosynthesis.
- explain what are transgenic plants and animals.
- describe different applications related to transgenic plants and animals.
- explain mechanisms in metabolic engineering and stem cell technology.
- explain different applications in medical biotechnology.
- describe what is bioremediation.
- appraise methods of bioremediation.
- design bioremediation plant and construct organisms with bioremediation ability.

Course Content:

Microbial Biotechnology: commercial production of microorganisms, products from microorganisms; plant and animal biotechnology: plant tissue culture and somatic cell genetics, application in genetic engineering, constructing and application of transgenic plants and animals, plant as bioreactors, molecular pharming, metabolic engineering and hairy root culture for secondary plant products, stem cell technology and organ transplantation; medical biotechnology: recombinant pharmaceuticals, xenotransplantations, DNA vaccines, therapeutic ribozymes, antibody engineering, industrial enzymes; Bioremediations: oil spills, waste water and heavy metal regulation; global status and bio safety of GMO and ethical issues.

Method/s of Evaluation:

End of the semester examination

Recommended Readings:

(i) Molecular Biotechnology: Principles and Application of Recombinant DNA (B.R. Glick & J.J. Pasternak)
(ii) Molecular Cell Biology (H. Lodish, M.P. Scott, P. Matsudaira & J. Darnell).

Course Code and Title:

MB 4901- Medical Biotechnology

Credit value:

2C

Rationale:

Medical biotechnology is an area of biotechnology which is applied to the manufacture of pharmaceuticals like enzymes, antibiotics and vaccines, and used for molecular diagnostics. This course unit is designed to provide insights into the cutting edge biotechnological approaches in medical biotechnology.

Pre-requisites:

None

Intended Learning Outcomes:

Upon completion of this course students should be able to:

- explain how to design and organize a molecular diagnostic laboratory.
- describe the standard operating procedures for sample processing and quality assurance for molecular diagnostics.
- describe the application of molecular biology techniques in the diagnosis of infectious diseases, blood disorders, diagnostic oncology, and identity testing.
- describe the use of molecular therapeutics and recombinant proteins in medical practice.
- discuss the advances made in human gene therapy trials.
- describe the applications of Cytogenetics and Hybridoma technology in medicine.
- describe how bio-industry contributes to bio-economy.
- explain the impact of genome projects on medical biotechnology.
- discuss the applications of biopharmaceuticals, vaccines**,** stem cells, gene therapy, in human diseases.
- explain the applications of genomic information to personalize therapies.
- discuss the legal, management and regulatory issues in usage of biotechnology products for human therapy.

Course Content:

Biotechnology, bio-industry and bio-economy, current achievements and innovation prospects, genome projects and their influence on medical biotechnology, biopharmaceuticals, (haemopoietic growth factors, blood coagulation products, thrombolytic agents, anticoagulants, interferons, interleukins, therapeutic enzymes),vaccines, monoclonal antibodies, nanomedicine, regenerative medicine**,** cancer immunotherapy, antimicrobials**,** stem cells, tissue engineering and transplantation, transgenics, gene therapy, pharmacogenomics and personalized medicines, clinical trials, health care law management, regulatory issues, perspectives: future developments. molecular diagnostics; design a laboratory for molecular diagnosis-basic principles, aspects on sample processing and quality assurance, applications in infectious diseases, applications in blood disorders, applications in diagnostic oncology, applications in identity testing, molecular therapeutics used in medicine, advanced human gene therapy trials, uses of recombinant proteins medical practice, cytogenetics- analysis of human genetic disorders, hybridoma technology – application in medicine.

Method/s of Evaluation:

End of semester examination

Recommended Readings:

(i) Comprehensive Biotechnology (Murray, Moo-Young).

Course Code and Title;
MB 4902 - Environmental Biotechnology
Credit value:
2C
Rationale:
This course unit is mainly aimed to provide insights into the novel biotechnological approaches in managing environmental contaminants and potential trends in decontamination of environment.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- explain the process of bioremediation.
- explain the principles of biodegradation and possibilities of manipulation, using biotechnology.
- describe the different molecular techniques which are used in detection of contaminated environments.
- explain and compare the different bioremediation approaches.
- justify the use of microbes in bioremediation.
- explain the process of phytoremediation.
- provide suggestions to optimize bioremediation using molecular techniques.

Course Content:
Fundamentals and techniques in biodegradation, principles and related molecular techniques in bioremediation**,** microarray technique for detection of microbes in natural and contaminated environments, metagenomic approaches in bioremediation, *in-situ* bioremediation, bioaugmentation strategy for treating persistent pollutants, bioavailability and bio accessibility of pollutants, proteomic techniques in revealing metabolic pathways in microbes involved in degradation of aromatic organic compounds, bioremediation and biodegradation of nitroaromatic explosives, optimization of bioremediation, biotechnological approaches in environmental decontamination, current progress and future prospects of phytoremediation, biological waste and waste water treatment, bio-treatment of drinking water, biodegradation of micropollutants.
Method/s of Evaluations:
Mid semester presentations (20%) and end of semester examinations (80%)
Recommended Readings:
(ii) Molecular Biotechnology: Principles &applications of recombinant DNA (Bernard, R. Glick., Jack J. Pasternak)
(iii) Comprehensive Biotechnology (Murray, Moo-Young).

Course Code and Title:
MB 4903– Marine Biotechnology
Credit value:
2C
Rationale:
This course unit is designed to provide insights into principles and applications in marine biotechnology.
Pre-requisites:
None
Intended Learning Outcomes:
Upon completion of this course students should be able to:

- describe the importance of 'Marine Biotechnology' as an indispensable component in biotechnology.
- compare and contrast the different marine bio resources which can be used in the advancement of biotechnology.
- explain how to use modern molecular biological techniques to investigate marine bio-resources.
- explain the different fields of marine biotechnology.
- use interdisciplinary knowledge to develop different areas of marine biotechnology.

Course Content:
Introduction to Marine Biotechnology: Different marine flora and fauna, phototrophs, viruses, microalgae, seaweed, coral, and sponges, production, cultivation and processing of flora and fauna. The tools and method of marine biotechnology: bioprocess engineering, bioinformatics techniques, bioreactors, transgenic technology, quorum sensing, and molecular methods for the detection of invasive species. Marine metagenomics, proteomics, and supporting technology, microfluidic systems, and genomic mining, algal biotechnology, marine-derived metabolites, mariculture, culturing fish and shellfish species, applications in marine biotechnology, marine pharmaceuticals, cosmeceuticals, nutraceuticals, biofuels, biosensors.
Method/s of Evaluation:
End of semester examination (70%) and continuous Method/s of Evaluations (up to 30%)
Recommended Readings:
(i) Springer Hand book of Marine Biotechnology (Se-Kwon, Kim).

Course Code and Title:

MB 4904 -Selected Topics in Biotechnology

Credit value:

2C

Rationale:

This course unit is designed to provide a broad knowledge on cutting edge techniques in biotechnology which can be essentially used for the development of industry, agriculture and health sector.

Pre-requisites:

None

Intended Learning Outcomes:

At the end of the lecture series students should be able to:

- explain the principles and impact of the latest and advanced techniques in biotechnology.
- describe the standard operating procedures for sample processing and quality assurance of biotech products.
- explain the national and international regulations for biotech products and processes.
- discuss the ethical issues of biotechnological applications in industry, agriculture and health sector.
- design the concepts for the future advancement of the field of biotechnology.

Course Content:

Fermentation technology and its applications, different techniques in product development using recombinant DNA technology, fungal biotechnology in food and feed processing, principles and techniques in bio-fuel production, principles and applications of synthetic biology, metabolic engineering of plants, industrial enzyme production and validation, development of non-structured bio-catalysts (Enzymes in nano-structures),heterologous protein expression systems and techniques, regulations of biotechnology and its products, ethical considerations in biotechnology.

Method/s of Evaluation:

End of semester examination (70%) and continuous Method/s of Evaluations (up to 30%)

Recommended Readings:

(i) Molecular Biotechnology: Principles &applications of recombinant DNA (Bernard, R. Glick., Jack J. Pasternak)

(ii) Comprehensive Biotechnology (Murray, Moo-Young).