AC/I(21-22).2(II).RUS9

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

RUIA COLLEGE
Explore • Experience • Excel

Syllabus for F.Y

Program: BSc

Program Code: Microbiology (RUSMIC)

(Choice Based Credit System for academic year 2022–2023)

PROGRAM OUTCOMES

PO	PO Description

	A student completing Bachelor's Degree in Science program will be able to:
PO 1	Recall and explain acquired scientific knowledge in a comprehensive manner and apply the skills acquired in their chosen discipline. Interpret scientific ideas and relate its interconnectedness to various fields in science.
PO 2	Evaluate scientific ideas critically, analyse problems, explore options for practical demonstrations, illustrate work plans and execute them, organise data and draw inferences.
PO 3	Explore and evaluate digital information and use it for knowledge upgradation. Apply relevant information so gathered for analysis and communication using appropriate digital tools.
PO 4	Ask relevant questions, understand scientific relevance, hypothesize a scientific problem, construct and execute a project plan and analyse results.
PO 5	Take complex challenges; work responsibly and independently, as well as in cohesion with a team for completion of a task. Communicate effectively, convincingly and in an articulate manner.
PO 6	Apply scientific information with sensitivity to values of different cultural groups. Disseminate scientific knowledge effectively for upliftment of the society.
PO 7	Follow ethical practices at work place and be unbiased and critical in interpretation of scientific data. Understand the environmental issues and explore sustainable solutions for it.
PO 8	Keep abreast with current scientific developments in the specific discipline and adapt to technological advancements for better application of scientific knowledge as a lifelong learner

PROGRAM SPECIFIC OUTCOMES

PSO	Description **A student completing Bachelor's Degree in Science program in the subject of Microbiology will be able to:**
PSO 1	Recall, explain and summarize basic concepts related to cytology, biochemistry, physiology, genetics and reproduction of prokaryotes and compare it with eukaryotes.
PSO 2	Appreciate and exemplify the diversity in the microbial world and evaluate their ecological role as well as state their significance to humankind.
PSO 3	Understand the basic concepts associated with growth and control of microorganisms and apply it in pure culture and preservation techniques.
PSO 4	Differentiate, classify and characterize microorganisms based on their morphological, cultural, biochemical, and molecular properties.
PSO 5	Explore, compare and evaluate the role of microorganisms in different natural environments as well as plants, animals and humans, and evaluate and exemplify their interrelationships.
PSO 6	Apply the understanding of microbial processes to diverse science areas such as medical, industrial, agricultural and food and evaluate their potential for human well-being, for tackling environmental issues and exploring sustainable solutions
PSO 7	Recall and explain the nature of biomolecules and metabolic processes; the role and kinetics of enzymes as well as the thermodynamic laws that drive these reactions.
PSO 8	Recall the basic working principles of various bioanalytical techniques and tools and apply them to detect, estimate and structurally evaluate biomolecules present in the microbial cells.
PSO 9	Understand and explain the nature of genetic material and elaborate the molecular mechanisms underlying various genetic processes like replication, transcription, translation, gene transfer and recombination in bacteria; and explain basic concepts in virology.

PSO 10	Apply the basics of genetics and molecular biology to understand and evaluate techniques in genetic engineering and also for the use of bioinformatic tools for presentation and processing of data.
PSO 11	Recognize and explain the role of microorganisms in different diseases, attribute pathogenesis mechanisms to their properties and extrapolate it to disease diagnosis, treatment and prevention. Outline and recall concepts in epidemiology of diseases. Classify and evaluate different chemotherapeutic agents.
PSO 12	Recall, classify and summarize mechanisms of defense in humans, detail out the functioning of our immune system, correlate it to disease and its prevention and outline its association to health. Apply immunological principles for diagnosis of diseases.
PSO 13	Understand and outline different biochemical mechanisms and their regulation; retrieve and construct biochemical pathways in microbial metabolism of major macromolecules and, recall and integrate the bioenergetics of metabolic reactions.
PSO 14	Evaluate, exemplify and outline the role of microorganisms in different industrial fermentations, summarize technological aspects of bioprocesses, recall knowledge about patents, copyright and regulatory practices and QA.
PSO 15	Demonstrate key practical skills/competencies in working with microbes for their study and use in the laboratory as well as outside, including the use of good microbiological practices. Analyze problems involving microbes, articulate them and devise innovative and creative solutions.
PSO 16	Hypothesize, design experiments, construct experimental plans, execute them and analyze data with a basic understanding of statistics. Demonstrate an ability to be unbiased and critical in interpretation of scientific data

PSO 17	Communicate effectively to express scientific ideas and/or their experimental data in an effective, precise and concise manner.

PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS
FY	I	RUSMIC 101 Core course	Fundamentals of Microbiology	02
		RUSMIC 102 Core course	Techniques in Microbiology	02
		RUSMICP101 Core course	Practical based on above two courses	02
	II	RUSMIC 201 Core course	Microbial world: types and inter-relations	02
		RUSMIC 202 Core course	Microbial biomolecules, Growth & Control	02
		RUSMICP201 Core course	Practical based on above two courses	02
SY	III	RUSMIC 301	Microbial taxonomy and Introduction to Genetics and Molecular Biology	02
		RUSMIC 302	Introduction to Experimental Microbial Biochemistry	02
		RUSMIC 303	Environmental Microbiology	02
		RUSMICP301	Practicals based on above three courses	03

	IV	RUSMIC 401	Microbe interactions and host responses	02
		RUSMIC 402	Introduction to Metabolic Pathways and Enzymology	02
		RUSMIC 403	Applied Microbiology	02
		RUSMICP401	Practicals based on above three courses	03
TY	V	RUSMIC 501	Microbial Genetics	2.5
		RUSMIC 502	Medical Microbiology	2.5
		RUSMICP501	Practical Based on Above Two Courses	3
		RUSMIC 503	Microbial Biochemistry: Part-I	2.5
		RUSMIC 504	Bioprocess Technology	2.5
		RUSMICP502	Practical Based on Above Two Courses	3
	VI	RUSMIC 601	Genetics, Bioinformatics & Virology	2.5
		RUSMIC 602	Immunology	2.5
		RUSMICP601	Practical Based on Above Two Courses	3
		RUSMIC 603	Microbial Biochemistry Part II	2.5
		RUSMIC 604	Industrial Microbiology	2.5
		RUSMICP602	Practical Based on Above Two Courses	3

Course Code: RUSMIC 101 Core Course

Course Title: Fundamentals of Microbiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand and explain the process of formation of earth and evolution of microorganisms on earth.
CO 2	Summarize the key events in the history of Microbiology
CO 3	Recognize the scope and relevance of Microbiology
CO 4	Recall and explain the nature, correlate function of components that make up a prokaryotic cell and identify them microscopically
CO 5	Compare and contrast between structural features of prokaryotic and eukaryotic cell
CO 6	Explain the types and role of normal flora on human body and infer its significance
CO7	Organizing the events of development of infection in human system and summarize the factors affecting host immune system

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 101		**FUNDAMENTALS OF MICROBIOLOGY**	**2/45**
I		**Evolution of Microbes, History and Future of Microbiology**	**15**
	1.1	**The Evolution of Microorganisms**	**05**
		a) Formation and Early History of Earth b) Origin of Cellular life. c) RNA world hypothesis and protein synthesis d) Microbial Diversification e) Endosymbiotic origin of prokaryotes f) Microbial Evolution - Process	
	1.2	**History, Branches and Scope of Microbiology**	**08**
		a) Discovery of microorganisms b) Conflict over spontaneous generation c) Golden Age of Microbiology-Koch Postulate, Medical Microbiology, Immunology d) Development of industrial microbiology and microbial ecology e) Scope and relevance of microbiology	
	1.3	**Future of Microbiology and unification with other sciences**	**02**
		a) Molecular and genomic methods to study microorganisms b) Emerging diseases c) Search for extra-terrestrial life d) Bio-based economies	
II		**Prokaryotic and Eukaryotic Cell Structure**	**15**
	2.1	**Prokaryotic Cell Structure and functions**	**10**
		a) Overview of prokaryotic cell structure b) Cell wall	

		c) Cell membrane d) Components external to cell wall-Capsule, Slime layer, Flagella, Pili, Fimbriae e) Cytoplasmic matrix-Inclusion bodies, magnetosomes, ribosomes, gas vesicles f) Nucleoid, Plasmids g) Bacterial endospores and their formation	
	2.2	**Eukaryotic Cell Structure**	**05**
		a) Overview of Eukaryotic cell structure b) Cytoplasmic matrix, microfilaments, intermediate filaments, and microtubules, Cilia and Flagella c) Organelles of the Biosynthetic-secretory and endocytic pathways –Endoplasmic reticulum & Golgi apparatus. Lysosome, Autophagy, Proteasome d) Eukaryotic ribosomes e) Mitochondria f) Chloroplasts g) Nucleus –Nuclear Structure h) Comparison of Prokaryotic and Eukaryotic Cells i) Mitosis & meiosis	
III		**Microbe- Human interactions**	
	3.1	**Normal flora of the human body**	**04**
		a) Skin, Nose & Nasopharynx, Oropharynx, Respiratory tract, Eye, External ear b) Mouth, Stomach, Small intestine, Large intestine c) Genitourinary tract d) Gnotobiotic animals e) Introduction to the concept of microbiome	

	3.2	**Development of infection** a) Portal of entry and infectious dose b) Attaching to host c) Surviving defenses d) Virulence factors e) Process of infection f) Portal of exit g) Patterns of an infection- localized, systemic, focal, mixed, primary, secondary, acute and chronic infections h) Signs and symptoms of disease	**07**
	3.3	**Host defense against infection: Overview**	**04**
		a) Factors affecting host defense: Species resistance, racial resistance and Individual resistance b) Introduction to innate and adaptive defences, Barriers at portal of entry: Physical barriers, Chemical defenses, genetic resistance.	

References:

a) Willey, Sherwood and Woolverton, Prescott's Microbiology, 9th edition, 2013, International edition, McGraw Hill.

b) Michael T. Madigan & J.M. Martin, Brock's Biology of Microorganisms 13th Ed. International edition 2012, Pearson Prentice Hall.

c) https://www.hort.purdue.edu/newcrop/ncnu02/v5-011.html

d) https://www.weforum.org/agenda/2018/04/can-a-nature-based-economy-help-us-drive-green-growth

a) Michael J. Pelczar Jr., E.C.S. Chan, Noel R. Krieg, Microbiology 5th Edition, 1986, Tata McGraw Hill Publishing Company Tortora, Funke and Case, Microbiology: An Introduction, 10th Edition, 2010, Pearson.

b) Kathleen Park Talaro & Arthur Talaro - Foundations in Microbiology International edition 2002, McGraw Hill.

c) Jacquelyn Black, Laura Black, Microbiology, Principles and Explorations, 9th Ed, 2015, Wiley

Course Code: RUSMIC 102 Core Course
Course Title: Techniques in Microbiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand and explain the principle, construction & functionality differences of various microscopes.
CO 2	Classify the microorganisms based on their growth requirements & explain the methods of cultivation of different microorganisms.
CO 3	Summarize the method & principle of the techniques used for visualization of microorganisms.
CO 4	Infer the significance of different preservation techniques & emphasize the role of Culture collection centres.
CO 5	Understand the design, working principle and applications of commonly used instruments in a microbiology laboratory
CO6	Comprehend biosafety levels and principle of containment
CO 7	Carry out basic staining and culturing techniques and test microbial activities using aseptic techniques

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 102		**Techniques in Microbiology**	**2/45**
I		**Cultivating & Visualizing Bacteria**	**15**
	1.1	**Microscopy**	10
		a) History of microscopy, Optical spectrum, Lenses and mirrors with ray diagrams b) Simple and compound light microscope c) Dark field Microscopy d) Phase contrast Microscopy e) Electron Microscopy f) Confocal Microscopy g) Fluorescence Microscopy	
	1.2	a) Morphological characteristics b) Staining procedures i. Dyes and stains: Types, Physicochemical basis, Fixatives, Mordants, Decolorizers ii. Simple and differential staining iii. Special Staining	**05**
II		**Nutrition and Cultivation of Microorganisms:**	**9**
	2.1	a) Nutritional requirements – Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorus, Sulfur and growth factors. b) Nutritional classification based on source of energy, electron and carbon c) Modes of nutrition: Endocytosis, Phagocytosis, movement of solutes across membranes d) Media Design and composition e) Types of Culture media with examples f) VBNC & oligotrophs g) Anaerobic cultivation	
	2.2	**Pure Culture Techniques**	**4**
		a) Streak plate method	

		b) Pour plate method c) Colony characteristics	
	2.3	**Preservation of microorganisms**	**02**
		a) Methods for maintenance and Preservation of Bacteria b) Culture Collection Centers	
III		**Basic Instrumentation & Biosafety**	**15**
	3.1	**Instrumentation - Construction, Working principle, application:**	**08**
		a) Overview of lab facility design and workflow b) Equipment for sterilization i) Autoclave ii) Hot air oven c) Equipment for cultivation i) Incubator ii) Water bath iii) Shaker iv) Anaerobic jars and work station d) Micropipettes e) Colorimeter f) Electrochemical sensors: pH meter	
	3.2	**Biosafety in Microbiology**	**07**
		a) Precautions to be taken while working in a Microbiology lab b) Biosafety- general principles and terminology with equipment c) Biological containment and laboratory safety levels d) Safe disposal of biohazardous waste e) Biowarfare & Bioterrorism	

References:

a) A.J.Salle, Fundamental Principles of Bacteriology, 1984, McGraw Hill publications
b) Michael J.Pelczar Jr., E.C.S. Chan ,Noel R , Microbiology TMH 5th Edition
c) Stanier, Ingraham et al, General Microbiology, 5th Ed.1987, Macmillan Education.
d) Tortora, Funke and Case, Microbiology: An Introduction, 6th Edition.1998, Pearson.

e) Michael T. Madigan & J.M. Martin, Brock's Biology of Microorganisms 13th Ed. International edition 2012, Pearson Prentice Hall.

f) Willey, Sherwood and Woolverton, Prescott's Microbiology, 7th edition, 2011, International edition, McGraw Hill.

Course code	Practical	2 Credits
RUSMIC P101	**PRACTICAL-1**	
Unit-I	1. Demonstration of Pasteur's experiment to refute Spontaneous Generation theory. 2. Demonstration of microbes in air, cough, on table surface, finger tips, fomites etc.	
Unit-II	1. Study of prokaryotic subcellular structures by special staining: Cell wall, capsule, endospore, flagella, lipid, metachromatic granules. 2. Study of Motility (Hanging Drop Preparation) 3. Wet mount of Hay infusion	
Unit-III	1. Normal flora of the skin, oral cavity and intestine. 2. Role of fomites 3. Cough plate technique	
RUSMIC P102	**PRACTICAL-2**	
Unit-I	1. Parts of a microscope 2. Micrometry 3. Dark field and Phase Contrast Microscopy: (Demonstration) 4. Monochrome staining 5. Gram staining 6. Negative Staining	
Unit-II	1. Nutritional requirements- Designing media using food material 2. Preparation of standard laboratory Culture Media: a. Liquid medium (Nutrient Broth) b. Solid Media (Nutrient agar, Sabouraud's agar)	

	c. Preparation of slant, butts& plates 3. Inoculation techniques and Study of Growth: a. Inoculation of Liquid Medium b. Inoculation of Solid Media (Slants, Butts and Plates) 4. Pure culture techniques- Streak plate method 5. Study of Colony Characteristics of bacteria. 6. Use of Differential & Selective Media: (MacConkey& Salt Mannitol Agar), Enriched (Blood Agar) 7. Cultivation in defined and crude media-Demonstration 8. Effect of environment on growth a. Temperature b. pH c. Osmotic pressure 9. Methods of Preservation of culture- Soil stock, oil overlay and preparation of glycerol stocks	
Unit-III	1. Working principle, architecture and applications of: a) Autoclave b) Hot air oven c) Incubator d) Anaerobic jars and work station e) Water bath f) Shaker g) Colorimeter h) Electrochemical sensors: pH meter 2. Working in a laminar air flow	

Modality of Assessment

Theory Examination Pattern:

A. **Internal Assessment- 40%- 40 Marks per paper**

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B. **External Examination- 60%- 60 Marks per paper**

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be three questions each of 20 marks one on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1) A)	Any 3 out of 5	15	Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.2) A)	Any 3 out of 5	15	Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.3) A)	Any 3 out of 5	15	Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
	TOTAL	**60**	

Practical Examination Pattern:

A. **Internal Examination: 40%- 40 Marks**

Particulars	Paper I	Paper II
Journal	05	05
Experimental tasks	15	15
Total	**20**	**20**

B. **External Examination: 60%- 60 Marks**

Semester End Practical Examination:

Particulars	Paper I	Paper II
Laboratory work	25	25
Spots/Quiz/Viva	05	05
Total	**30**	**30**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / In charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination & Marks Distribution Pattern

Semester I

Course	101			102			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical	**20**	**30**	**50**	**20**	**30**	**50**	**100**

Course Code: RUSMIC 201 Core Course

Course Title: Microbial World: Types and inter-relations

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand the structure, cultivation and significance of viruses
CO 2	Explain and compare the features of Rickettsia, Chlamydia and Myxobacteria
CO 3	Summarize the characteristics and infer significance of Actinomycetes and Archaebacteria
CO 4	Categorize microorganisms like Protozoa, Algae and Fungi into different groups based on their characteristics
CO 5	Infer the medical and industrial significance of Protozoa, Algae and Fungi
CO 6	Recall & explain the role of microorganisms in biogeochemical cycles & in maintaining balance of the ecosystem
CO 7	Illustrate the different types of microbial interactions & explain the significance of extremophiles.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 201		**MICROBIAL WORLD: TYPES AND INTER-RELATIONS**	**2/45**
I		**Microbial diversity-I**	**15**
	1.1	**Viruses**	**06**
		a) Historical highlights, General properties of viruses, prions, viroids b) Structure of viruses-capsids, envelopes, genomes–TMV, Influenza, and T4 as representatives c) Cultivation of viruses- overview	
	1.2	**Domain Bacteria-** General characteristics and list of genera of every group with emphasis on mentioned genera a) Proteobacteria- Rickettsia, Caulobacter, Spirillum, Pseudomonas, Escherichia, Vibrio, Bdellovibrio, Myxobacteria b) Non-proteobacteria Cyanobacteria, Chlamydia, Firmicutes-Clostridium, Mycoplasma, c) High G+C content bacteria- Mycobacteria, Actinobacteria	**09**
II		**Microbial diversity-II**	**15**
	2.1	**Archaea**	**03**

		a) Introduction- Major Archaeal physiological groups, b) Archaeal cell wall, lipids and membranes c) Ecological importance	
	2.2	**Protozoa**	**03**
		a) General characteristics b) Major categories of Protozoa based on motility, reproduction c) Medically important Protozoa	
	2.3	**Algae**	**04**
		a) Characteristics of algae: morphology, Pigments, reproduction b) Cultivation of algae c) Major groups of Algae –an overview d) Biological, Medical and economic importance e) Medical, ecological &Commercial application	
	2.4	**Fungi and Yeast**	**04**
		a) Characteristics: structure, Reproduction b) Cultivation of fungi and yeasts c) Major fungal divisions- overview d) Life cycle of yeast e) Biological and economical importance	
	2.5	**Slime molds**	**01**
III		**Microbes in Natural Environments**	**15**
	3.1	**Microorganisms in Nature**	**03**
		a) Microenvironments b) Introduction to microbial biofilms c) Mixed populations and microbial consortia d) Introduction to Quorum Sensing	
	3.2	**Role of microbes in Biogeochemical cycles**	**06**
		a) C- cycle, N- cycle, S- cycle, Iron cycle b) Interaction between elemental cycles	
	3.3	**Microbial competition and cooperation**	**04**

		a) Types of Microbial Interactions: Mutualism, Cooperation, Commensalism, Predation, Parasitism, Amensalism, Competition with examples b) Functions of symbiosis c) Establishment of symbiosis	
	3.4	**Introduction to extremophiles with importance**	**02**

References:

a) Willey, Sherwood and Woolverton, Prescott's Microbiology, 9th edition, 2013, International edition, McGraw Hill.

b) Michael T. Madigan & J.M. Martin, Brock's Biology of Microorganisms 13th Ed. International edition 2012, Pearson Prentice Hall.

c) Michael J. Pelczar Jr., E.C.S. Chan, Noel R. Krieg, Microbiology 5th Edition, 1986, Tata McGraw Hill Publishing Company

d) Stanier, Ingraham et al, General Microbiology, 5th Ed. 1987, Macmillan Education Ltd.

Course Code: RUSMIC202 Core Course

Course Title: Microbial Biomolecules, Growth & Control

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Recall the characteristics and structures of biomolecules and classify and detect them in various samples
CO 2	Understand and explain the growth pattern with the phases of growth for bacteria.
CO 3	Summarize the physical, chemical &cultivation-based methods for enumeration of microorganisms.
CO 4	Recall & exemplify the mechanisms of physical & chemical antimicrobial agents.
CO 5	Execute & perform the techniques used for enumeration of microorganisms & evaluate the microbicidal action of physical & chemical agents.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 202		**Microbial Biomolecules, Growth & Control**	**2/45**
I		**Chemical basis of life**	**15**
	3.1	**Chemical foundations**	**02**
		a) Biomolecules as compounds of carbon with a variety of functional groups. b) Universal set of small molecules. c) Macromolecules as the major constituents of cells. d) Configuration and Conformation with definitions and suitable examples only. e) Types of Stereoisomers and importance of stereoisomerism in biology. f) Types of bonds and their importance: Hydrogen, van der Waal's, Electrovalence, covalent, ester, phosphodiester, thioester, peptide, glycosidic.	
	3.2	**Water- Structure, properties in brief**	**01**
	3.3	**Carbohydrates and glycobiology**	**04**
		a) Definition, Classification, Biological role. b) Monosaccharides, (Chair and boat conformation) oligosaccharides (maltose, cellobiose, sucrose, lactose) and polysaccharide (starch, glycogen, peptidoglycan, cellulose), glycoproteins (glycosaminoglycans and proteoglycans), glycome.	
	3.4	**Lipids**	**02**
		a) Fatty acids as basic component of lipids	

		b) Classification, nomenclature, storage lipids and structural lipids. c) Types of lipids with general structure of each and mention examples.	
	3.5	**Amino acids & proteins**	**03**
		a) General structure and features of amino acids (emphasis on amphoteric nature) b) Classification by R-group, Uncommon amino acids and their functions Peptides and proteins- Definition and general features and examples with biological role. c) Primary, secondary, tertiary, quaternary structures of proteins- Brief outline.	
	3.6	**Nucleic acids**	**03**
		a) Nitrogenous bases- Purines, Pyrimidines b) Pentoses-Ribose, Deoxyribose, c) Nomenclature of Nucleosides and nucleotides, d) N-β-glycosidic bond, e) polynucleotide chain to show bonding between nucleotides (Phosphodiester bonds). f) Basic structure of RNA and DNA	
II		**Microbial Growth**	**15**
	1.1	**Growth Curve & Mathematical Expression of Growth Curve**	**05**
		a) Definition of Growth, Growth phases b) Determining growth constant & growth rate	
	1.2	**Measurement of Growth**	**07**
		a) Direct microscopic count i) Breed's count, ii) Petroff-Hausser counting chamber iii) Haemocytometer b) Viable count using Spread plate and Pour plate technique c) Measurements of cell constituents. d) Turbidity measurements– Brown's opacity tubes and spectrophotometer techniques e) Coulter Counter	
	1.3	**Factors affecting growth pattern**	**03**

III		Control of Microorganisms	15
	2.1	**Definition of terms**	**01**
	2.2	**Physical agents for control of microorganisms (mode of action, advantages, disadvantages and applications)**	**07**
		a) High temperature-moist heat and dry heat b) Low temperatures c) Radiation d) Osmotic pressure e) Desiccation f) Physical removal of microorganisms using bacteriological filters	
	2.3	**Chemical agents for control of microorganisms (mode of action, advantages, disadvantages and applications of all major groups of antimicrobial agents)**	**05**
	2.4	**Evaluation of Chemical disinfectants**	**02**
	2.5	**Chemotherapeutic & antimicrobial agents- types & examples (tabular form)**	**01**

References:

a) Microbiology TMH 5th Edition by Michael J.Pelczar Jr., E.C.S. Chan ,Noel R. Krieg
b) A.J.Salle, Fundamental Principles of Bacteriology,1984, McGraw Hill Book Company
c) Prescott, Hurley Klein-Microbiology, 5th ed, International edition 2002, McGraw Hill.
d) Prescott's Microbiology, 7th Edition; Joanne M. Willey, Linda M. Sherwood, Christopher J.Woolverton, 2011, McGraw Hill International
e) Michael T.Madigan & J.M. Martin, Brock, Biology of Microorganisms 11th Ed. International edition, 2006, Pearson Prentice Hall.
f) Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, 7th edition, 2010, Cambridge University Press.
g) Conn P. Stumpf, G. Bruening and R. Doi, Outlines of Biochemistry 5/E, 1995, John Wiley & Sons. New York
h) D. Nelson and M. Cox, Lehninger's Principles of Biochemistry, 4th Edition, 2005, W.H. Freeman and Company

i) Laurence A. Moran, H. Robert Horton, K. Gray Scrimgeour, Marc D. Perry, Principles of Biochemistry, 5th Edition, 2012, Pearson

Course code	PRACTICALS	2 Credits
RUSMICP 201	**PRACTICAL-1**	
Unit-I	1. Demonstration of Bacteriophages in sewage 2. Isolation of Actinomycetes from soil and Slide Culture technique for Actinomycetes 3. Biogas production using methanogens 4. Cultivation of algae	
Unit-II	1. Isolation of yeast, and other fungi 2. Fungal Wet mounts & Study of Morphological Characteristics Mucor, Rhizopus, Aspergillus, Penicillium 3. Slide culture of fungi 4. Cultivation of fungi- static and shaker conditions 5. Permanent slides of Algae, Protozoa 6. Demonstration of protozoa in hay infusion	
Unit-III	1. Dip slide technique to demonstrate microbial biofilms 2. Crowded plate technique for demonstration of antibiosis 3. Demonstration of bacteroid forms of *Rhizobia*	
RUSMICP 202	**PRACTICAL-2**	
Unit-I	1. Qualitative detection of: a. Carbohydrates- Benedicts, Molisch's test. b. Proteins, amino acids- Biuret, Ninhydrin. c. Nucleic acid detection by DPA and Orcinol	
Unit-II	1. Study of growth curve of bacteria 2. Enumeration of microorganisms using Haemocytometer & Breed's Count 3. Enumeration of microorganisms Brown's opacity tubes 4. Viable count: Spread plate and pour plate	

Unit-III	1. Demonstration of efficiency of autoclave 2. Effect of UV Light on bacteria 3. Effect of surface tension on bacterial growth 4. Study of Oligodynamic action 5. Effect of dyes, phenolic compounds and chemotherapeutic agents on bacteria- disc diffusion method 6. Demonstration of MIC of an antibacterial agent	

Modality of Assessment

Theory Examination Pattern:

A. **Internal Assessment- 40%- 40 Marks per paper**

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B. **External Examination- 60%- 60 Marks per paper**

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be three questions each of 20 marks one on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1) A)	Any 3 out of 5	15	Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.2) A)	Any 3 out of 5	15	Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.3) A)	Any 3 out of 5	15	Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
	TOTAL	**60**	

Practical Examination Pattern:

A. **Internal Examination: 40%- 40 Marks**

Particulars	Paper I	Paper II
Journal	05	05
Experimental tasks	15	15
Total	**20**	**20**

B. **External Examination: 60%- 60 Marks**

Semester End Practical Examination:

Particulars	Paper I	Paper II
Laboratory work	25	25
Spots/Quiz/Viva	05	05
Total	**30**	**30**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination & Marks Distribution Pattern

Semester II

Course	201			202			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**100**

AC/I(21-22).2(II).RUS9

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for S.Y, T.Y

Program: BSc

Program Code: Microbiology (RUSMIC)

(Credit Based Semester and Grading System for academic year 2022-23)

Course Code: RUSMIC 301

Course Title: MICROBIAL TAXONOMYAND INTRODUCTION TO GENETICS AND MOLECULAR BIOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Differentiate between vast pool of microbes on the basis of morphological, cultural, biochemical and genetic characteristics
CO 2	Understand, apply and evaluate techniques in microbial taxonomy
CO 3	Construct phylogenetic trees using simple computational tools
CO 4	Recall Mendelian genetics and critique the deviations from Mendelian genetics
CO 5	Discriminate the structure of DNA and RNA focusing on the different forms of DNA
CO6	Understand the central dogma of molecular genetics
CO7	Explain prokaryotic transcription and translation process and interpret the significance of the important events from initiation to the termination of the process
CO8	Extrapolate the role of omics in molecular biology studies

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 301		**MICROBIAL TAXONOMY AND INTRODUCTION TO GENETICS AND MOLECULAR BIOLOGY**	**2 / 45**
I		**Techniques in Microbial Taxonomy**	**15**
	1.1	**Introduction to microbial Taxonomy and Taxonomic ranks**	**01**
	1.2	**Techniques for studying Microbial Taxonomy**	**08**
		a) Microscopic & macroscopic morphology and biochemical characteristics, b) Chemical Analysis c) Serological analysis d) Genetic & molecular analysis: i. Nucleic acid sequencing and finger printing ii. G+C content iii. Nucleic acid hybridization iv. Amino acid sequencing e) Community DNA analysis	
	1.3	**Introduction to Microbial Phylogeny**	**05**
		a) Phylogenetic Trees i. Types ii. Construction (an overview) b) Numerical Taxonomy	
	1.4	**Bergey's Manual of Systematic Bacteriology**	**01**
		a) Understanding classification and identification schemes for bacteria using Bergey's manual	
II		**Classical Genetics (Mendelian & Neomendelian) & Nucleic acid structure**	**15**
	2.1	**Mendelian genetics:**	**04**
		a) Genotype and Phenotype	

		b) Mendel's Experiments design c) Monohybrid cross and dihybrid cross, Mendelian Laws of inheritance a) Trihybrid Cross	
	2.2	**Non-Mendelian genetics**	**05**
		a) Multiple alleles b) Modification of dominance relationships c) Incomplete dominance d) Codominance (both with their molecular explanations) e) Essential and lethal genes f) Gene expression and effect of environment g) Maternal effect h) Gene interactions and modified Mendelian ratios	
	2.3	**Structure of DNA:**	**03**
		Different 3D forms and unusual structures DNA methylation	
	2.4	**Structure of chromosomes**	**01**
	2.5	**Structure of RNA**	**02**
III		**Gene Expression in Bacteria**	**15**
	3.1	**Central dogma of Molecular Biology**	**01**
	3.2	**Transcription in prokaryotes**	**06**
		a) RNA biosynthesis b) Prokaryotic transcription i. Prokaryotic promoters ii. Initiation, elongation and termination	
	3.3	**Translation**	**06**
		a) Components of protein synthesis apparatus: Genetic code, mRNA, Ribosomes b) Degeneracy of genetic code c) Protein synthesis	

	3.4	**Comparison of eukaryotic & prokaryotic transcription & translation**	**01**
	3.5	**Introduction to the concept of Omics: Genomics and Proteomics**	**01**

References:

a) Prescott‟s Microbiology, Joanne M. Willey, Linda M. Sherwood, Christopher J.Woolverton, Edition, 7th Edition, 2011, McGraw Hill International
b) Madigan, Martinko, Dunlap and Clark, Brock Biology of Microorganisms, 12thedition, 2009, Pearson Education
c) Peter J. Russell, “iGenetics - A molecular approach”, 3rd edition, 2010, Benjamin Cummings.7
d) Stanier R.Y. And Other, MacMillan General Microbiology, 5th edition,1987, MACMILLAN PRESS LTD
e) D. Nelson & M. Cox, Lehninger‟s Principles Of Biochemistry,4th Edition ,2005, (W.H.Freeman& Co., (LPE)
f) James Watson, Molecular Biology of Gene, 5th edition,2004, Pearson Benjamin Cummings CSHL Press.
g) Benjamin A Pierce, Genetics: A conceptual approach ,2002, W.H. Freeman

Course Code: RUSMIC 302

Course Title: INTRODUCTION TO EXPERIMENTAL MICROBIAL BIOCHEMISTRY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand the process of designing experiments & analyse the experimental data statistically.
CO 2	Implement the use of web directories & databases for biochemical studies
CO 3	Recall & compare the different cell disintegration methods & elaborate the working principles of centrifugation, electrophoretic & chromatographic techniques used for studying cell analytes.
CO 4	Illustrate the principles of protein separation & purification.
CO 5	Compare the utility & perform the techniques for the estimation of biomolecules.
CO 6	Understand the principle, instrumentation & application of different laboratory instruments used in biochemical studies.
CO 7	Design an experiment for extraction, purification & estimation of biomolecules, & evaluate the statistical relevance of the data generated.

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 302		**INTRODUCTION TO EXPERIMENTAL MICROBIAL BIOCHEMISTRY**	**2/45**
I		**Designing and Analysis of experimental data, General laboratory techniques: Electrochemical sensors**	**15**
	1.1	**Designing experiments:**	**02**
		a) Aims of laboratory experiments b) Outline of Scientific method c) Experimental design d) Analytical considerations and experimental error	
	1.2	**Analysis of experimental data:**	**07**
		a) Data presentation: Dot diagram, Bar diagram, Histogram, Frequency curve, Calibration methods: Linear regression, Internal standards b) Assessment of precision -Mean, Median, Mode, Standard deviation, coefficient of variation and variance c) Assessment of performance of an analytical technique -performance indicators d) Poisson and Normal distribution e) Assessment of accuracy& Validation of analytical data population statistics, confidence limit and confidence interval; Students t factor, Q test, F test, ANOVA	
	1.3	**Using computers in biochemistry**	**02**
		Using web directories, biological databases and tools (eg. NCBI, EMBL)	
	1.4	**General and routine laboratory procedures:**	**04**
		Theoretical and practical aspects of: a) Preparation and use of buffers	

		b) Electrochemical sensors: pH meter c) Oxygen electrode d) Biosensors	
II		**Fractionation of microbial cells and separation techniques**	**15**
	2.1	**Disintegration of cells**	**02**
		a) Physical methods b) Chemical methods	
	2.2	**Separation Techniques**	**03**
		a) Centrifugation techniques: i. Basic principles of sedimentation ii. Types of centrifuges and their use: preparative & analytical, ultracentrifuges iii. Differential, Density Gradient & isopycnic centrifugation	
		b) Electrophoretic techniques: i. General Principles ii. Factors affecting electrophoresis iii. Support media- Agarose gels and PAGE	**03**
		c) Chromatographic Techniques: i. General principles ii. Types and applications- Partition, adsorption, ion exchange, affinity and size exclusion iii. Modes- Paper, TLC, HPLC, GC, Reverse Phase	**07**
III		**Purification & Estimation of biomolecules**	**15**
	3.1	**Separation and purification of proteins**	**03**
		a) Criteria for purity b) Methods of separation/ concentration of proteins based on: i. Size and mass ii. Polarity iii. Solubility iv. Specific binding sites v. Concentration of proteins - Dialysis,	

		Ultrafiltration c) Choice of methods	
	3.2	**Estimation of Biomolecules**	**12**
		a) Visible and UV spectrophotometry i. Principles ii. Instrumentation **iii.** Applications **b)** Preparation of bacteria for analysis **c)** Methods for chemical analysis (Basic principles of all methods to be covered) i. Methods of elemental analysis: Carbon by Slyke's method, Nitrogen by Microkjelhdahl method, Phosphorus by Fiske-Subbarow method ii. Estimation of Carbohydrates by Phenol and Anthrone Method iii. Estimation of Reducing Sugars iv. Estimation of Proteins v. Estimation of Amino acids vi. Extraction of Lipids and estimation of total lipid vii. Estimation of Nucleic acids	03 01 08

References:

a) Norris & Ribbon, Methods in Microbiology, Vol.5B, Edition,1971, Academic Press

b) J. Jayaraman, Laboratory Manual in Biochemistry, 2003, New Age International Publishers

c) D. Nelson & M. Cox, Lehninger's Principles Of Biochemistry,4th Edition, 2005, W.H.Freeman & Co., (LPE)

d) B.K. Mahajan. Jaypee brothers, Methods in biostatistics for medical & research workers. 6thedition, Medical Publishers (P) ltd.

e) Rodney Boyer, Modern experimental biochemistry by 3rd Edition ,2000, Benjamin Cummings

f) I.H. Segel, Biochemical calculations, 2nd Edition 2004, Wiley India

g) Wilson and Walker, Principles and Techniques of Biochemistry and Molecular Biology 7th Ed ,2010. Cambridge University Press

h) Stanier R.Y. And Other, General Microbiology, 5th edition, 1989 MacMillan Press.

i) Plummer David, An Introduction to Practical Biochemistry ,1979, TMH

j) Wayne Daniel, Biostatistics: A Foundation for Analysis in Health Sciences, 10th edition, 2013, Wiley.

Course Code: RUSMIC 303

Course Title: ENVIRONMENTAL MICROBIOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand the distribution and characterization of microbes in various habitats/ecosystems
CO 2	Explain role of air as a medium of microbial dispersion
CO 3	Differentiate between microbial flora of marine and freshwater environments
CO 4	Execute microbiological techniques for studying microbiota of air, aquatic and terrestrial environments
CO 5	Implement routine bacteriological analysis techniques for assessing water quality and attribute the results to sources of contamination
CO 6	Recall steps in sewage treatment and check effectivity of treatment processes
CO 7	Implement microbiological analysis of a soil ecosystem with an understanding of the most appropriate technique
CO 8	Apply basic principles of environmental microbiology for understanding and solving environmental problems –bioremediation

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 303		**ENVIRONMENTAL MICROBIOLOGY**	**2/45**
I		**Air & Fresh Water Microbiology**	**15**
	1.1	**Air Microbiology**	**05**
		a) Origin, distribution, number and kinds of microorganisms in air, Factors affecting microbial survival in air b) Enumeration of microorganisms in air: Impingement in liquids, Impaction on solids, Filtration, Sedimentation, Centrifugation, Electrostatic Precipitation. c) Air borne pathogens and diseases, droplets and droplet nuclei d) Air sanitation- methods and application	
	1.2	**Fresh water microbiology**	**10**
		a) General: Groups of natural waters, factors affecting kinds of microorganisms found in aquatic environments and nutrient cycles in aquatic environments b) Fresh Water environments and microorganisms found in Lakes, ponds, rivers, marshes, bogs and springs c) Potable water: Definition, water purification and pathogens transmitted through water. d) Microorganisms as indicators of water quality **e)** Bacteriological examination of water-sampling, routine analysis, SPC, membrane filter technique, Standards for water quality	

II		**Marine and Sewage Microbiology**	**15**
	2.1	**Marine Microbiology**	**05**
		a) Characteristics of marine environments b) Diversity& characteristics of marine microorganisms and their importance c) Ecosystems of Deep-sea Hydrothermal vents and Subterranean Water	
	2.2	**Sewage Microbiology**	**10**
		a) Types of waste water b) Characteristics of waste water c) Modern waste water treatment: Primary, Secondary and tertiary treatment (oxidation ponds, activated sludge, trickling filters, anaerobic digestor). d) Removal of pathogens by sewage treatment Processes e) Sludge Processing f) Disposal of Solid Waste, Modern Sanitary Landfills, Composting	
III		**Soil & Geo Microbiology**	**15**
	3.1	**Soil Microbiology**	**03**
		a) Soil – Definition, composition, function, Textural Triangle Types of Soil microorganisms & their activities	
	3.2	**Methods of studying soil microorganisms**	**05**
		a) Sampling b) Cultural methods c) Physiological methods	

		d) Immunological methods (Tabulation of the immunological methods) e) NA based method f) Radioisotope technique	
	3.3	**Geo Microbiology**	**03**
		a) Carbon cycle b) Nitrogen cycle c) Sulphur cycle d) Phosphorus cycle	
	3.4	**Biodegradation and Bioremediation**	**4**
		a) Microbial leaching b) Metal transformations c) Petroleum degradation d) Degradation of xenobiotics	

References:

a) Raina M. Maier, Ian L. Pepper, Charles P. Gerba, Environmental Microbiology, 2nd Edition,2010, Academic Press
b) A.J. Salle, Fundamental Principles of Bacteriology, 7th Editon,1974, Tata McGraw Hill Publishing Company
c) Air Quality Standards - NAAQS Manual, Volume I, 2011
d) Joanne M. Willey, Linda M. Sherwood, Christopher J.Woolverton Prescott‟s Microbiology, 8th Edition,2011 , McGraw Hill International Edition
e) Frobisher, Hinsdill, Crabtree, Goodheart, Fundamentals of Microbiology, 9th Edition, 1974, Saunders College Publishing
f) Barbara Kolwzan, Waldemar Adamiak (E Book) Oficyna Wydawnicza Politechniki Wroclawskiej, Wroclaw, 2006
g) N.S Subba Rao, Introduction to Environmental Microbiology –Soil Microbiology -4th Edition ,2000, Oxford and IBH Publishing Co. Pvt Ltd
h) Michael T. Madigan & J.M. Martin, Brock’s Biology of Microorganisms 13th Ed. International edition 2012, Pearson Prentice Hall.

Course code	PRACTICALS	3 CREDITS
RUSMICP301	**PRACTICAL-1**	
	1. Isolation and identification of a bacterial isolate 2. Problems on Mendelian genetics 3. Extraction of DNA from onion and *E. coli* 4. Problems on genetic code 5. Construction of phylogenetic tree.	
RUSMICP302	**PRACTICAL -2**	
	1. Introduction to experimental design 2. Lab common sense workshop 3. Biostatistics problems 4. Study of pH meter and preparation of buffers 5. Density gradient centrifugation 6. Demonstration of agarose gel electrophoresis 7. Demonstration of PAGE 8. Separation of amino acids using paper chromatography 9. Separation of carbohydrates using TLC 10. Demonstration of column chromatography 11. Demonstration of HPLC, HPTLC and GC 12. Determination of λmax 13. Verification of Beer's law and determination of extinction coefficient 14. Large scale cultivation of bacteria /yeast/ fungi 15. Determination of Dry and wet Weight 16. Disintegration of cells using physical & chemical methods and separation of biomolecules 17. Estimation of Amino acids by Ninhydrin method 18. Estimation of Proteins by Biuret method 19. Bradford's Method for protein estimation 20. Estimation of Reducing Sugars by DNSA method	

	21. Estimation of RNA by orcinol method 22. Estimation of DNA by diphenylamine method Note: All the above methods will also be analyzed using statistical methods covered in theory	
RUSMICP303	**PRACTICAL-3**	
	1. Enumeration of microorganisms in air and study its load after fumigation 2. Determination of microbial load using air impinger 3. Study of halophilic and haloduric bacteria from marine samples 4. Routine analysis of water 5. Use of membrane filter technique for bacteriological analysis of water 6. Rapid detection of *E.coli* by MUG technique-Demo 7. Visit to a Sewage treatment plant 8. BOD of untreated and treated sewage 9. Buried slide technique to study soil flora 10. Enrichment and isolation of Cellulose degraders, Sulphate reducers and Phosphate solubilizers from soil 11. Setting up Winogradsky's Column 12. Developing compost pits	

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks per paper

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks per paper

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be three questions each of 20 marks one on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1) A)	Any 3 out of 5	15	Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.2) A)	Any 3 out of 5	15	Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.3) A)	Any 3 out of 5	15	Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 60 Marks

Particulars	Paper I	Paper II	Paper III
Journal	05	05	05
Experimental tasks	15	15	15
Total	**20**	**20**	**20**

B) External Examination: 60%- 90 Marks

Semester End Practical Examination:

Particulars	Paper I	Paper II	Paper III
Laboratory work	25	25	25
Spots/Quiz/Viva	05	05	05
Total	**30**	**30**	**30**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination & Marks Distribution Pattern

Semester III

Course	301			302			303			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**300**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**150**

Course Code: RUSMIC 401

Course Title: Microbe Interactions and Host Responses

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Exemplify microbial interactions with plants, animals and other microorganisms
CO 2	Evaluate the ecological, medical and evolutionary significance of microbial interactions with plants, animals and other microorganisms
CO 3	Outline the strategies through which pathogens develop infections and demonstrate presence of some virulence factors in known isolates
CO 4	Understand the concepts and terminologies used in epidemiology and correlate disease transmission to disease control
CO 5	Apply the understanding of epidemiology studies in solving public health concerns
CO6	Understand the key components of innate and acquired immune system and summarize their role in overcoming disease
CO7	Compare the different types of immunoglobulins and understand their function in protection

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 401		**MICROBE INTERACTIONS AND HOST RESPONSES**	**2/45**
I		**Microbial interactions with plants, animals and other microbes**	**15**
	1.1	**Microbial associations with plants**	**08**
		a) Phyllosphere b) Rhizosphere & Rhizoplane c) Mycorrhizae d) Nitrogen fixation: Biochemistry of nitrogen fixation, nodulation in *Rhizobia*, *Azolla-Anabena* symbiosis, Actinorhizae, Stem nodulating *Rhizobia* e) Fungal & Bacterial endophytes f) Plant pathogens -Fungal, bacterial and viral diseases	
	1.2	**Microbial interactions with animals**	**05**
		a) Microbial symbionts in invertebrates b) Bacterial flora in the Rumen c) Microbe- insect interactions d) Introduction to Zoonotic diseases	
	1.3	**Microbe - Microbe interactions**	**02**
		a) Lichen b) Endosymbionts of Protozoa c) Parasitism in microbes	
II		**Microbial invasion in Human hosts**	**15**
	2.1	**Virulence Mechanisms**	**08**
		a) Bacterial virulence factors i. Adherence factors ii. Invasion of host cells and tissues iii. Toxins- Exotoxins and Endotoxins iv. Enzymes	

		v. Evading host defense- Antigenic variation, Antiphagocytic factors and Intracellular pathogenicity vi. Iron sequestration vii. The role of Biofilms	
		b) Measuring bacterial virulence: Infective dose & Lethal dose, limulus amoebocyte assay c) Pathogenic properties of viruses, fungi and protozoa	
	2.2	**Introduction to epidemiological concepts**	**07**
		a) Reservoirs of infection b) Modes of disease transmission c) Nosocomial infections d) Epidemiological terminology: epidemic, endemic, pandemic, sporadic, incidence rate, prevalence rate, mortality, morbidity e) Controlling epidemics: Controlling reservoirs, controlling transmission- Immunization strategies- passive and active, Surveillance	
III		**Host responses to infection**	**15**
	3.1	**Cells, Tissues and Organs of the Immune System**	**04**
		a) Cells of the immune system- Lymphoid and Myeloid cells, NK cells b) Organs of the immune system- Introduction to primary and secondary lymphoid organs and their roles	
	3.2	**Immune responses- Innate defense mechanisms**	**04**
		a) Phagocytosis – Recognition, Destruction, b) Inflammation- Acute and Chronic c) Fever d) Molecular defenses- IFN, complement, ACP	
	3.3	**Immune responses- Acquired Defense**	**07**
		a) Outline and characteristics of Adaptive Immune response b) Immunoglobulins – basic and fine structure c) Immunoglobulin classes and biological activities d) Antigenic determinants on immunoglobulins – isotypes, allotypes, idiotypes	

		e) Protective functions of antibodies- Opsonization, Complement mediated lysis, viral neutralization and toxin neutralization f) Introduction to Cell mediated immunity	

References:

a) Willey, Sherwood and Woolverton, Prescott's Microbiology, 9th edition, 2013, International edition, McGraw Hill.
b) Michael T. Madigan & J.M. Martin, Brock's Biology of Microorganisms 13th Ed. International edition 2012, Pearson Prentice Hall.
c) Stanier, General microbiology 5th edition ,1987, Macmillan publication
d) Tortora, Funke and Case, Microbiology: An Introduction, 10th Edition, 2010, Pearson.
e) Kathleen Park Talaro & Arthur Talaro - Foundations in Microbiology International edition 2002, McGraw Hill.
f) Jacquelyn Black, Laura Black, Microbiology, Principles and Explorations, 9th Ed, 2015, Wiley
g) Brooks, Carroll, et al, Jawetz, Melnick &Adelberg's Medical Microbiology, 26th Ed McGraw Hill Lange 2013
h) https://www.eurofins.com.au/biopharma-services/testing-solutions/sterile-products-testing/endotoxin-or-lal-test/
i) Ingraham and Ingraham, Introduction to Microbiology, by 2nd Ed ,2000, Brooks/Cole
j) Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, Kuby Immunology, 6th ed, W. H. Freeman & Company 2005

Course Code: RUSMIC 402

Course Title: INTRODUCTION TO METABOLIC PATHWAYS AND ENZYMOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand the concepts and types of metabolism. Compare the metabolic strategies & recall the role of Omics in biochemical studies
CO 2	Explain the regulatory junctions of metabolic pathways.
CO 3	Recall the properties & classes of enzymes. Illustrate enzyme-substrate interaction models & recognize the significance of cofactors & coenzymes.
CO 4	Evaluate enzyme kinetics & the change in activity in presence of variables.
CO 5	Explain the principles of Bioenergetics & attribute the role of energy currency molecule
CO 6	Understand & apply the laws of thermodynamics to microbial metabolism.
CO 7	Implement experimental procedures for enzyme purification and enzyme kinetics studies

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 402		**INTRODUCTION TO METABOLIC PATHWAYS AND ENZYMOLOGY**	**2/45**
I		**Introduction to Metabolism**	**15**
	1.1	**Introduction to biochemical reactions:**	**04**
		a) Key reactions involved in metabolism. b) Weak interactions involved in determining the structures and functions of macromolecules.	
	1.2	**Introduction to metabolism:**	**06**
		a) Metabolism- Catabolism & Anabolism b) Types of Metabolic pathways c) Metabolic networks, use of different software d) Primary and secondary metabolism e) Energy and reducing power requirements	
	1.3	**Metabolic strategies: Managing metabolic network**	**04**
		a) Role of enzymes, enzyme clustering & multienzyme complexes b) Functional coupling **c)** Compartmentalization in cells	
	1.4	**Introduction to omics: Metabolome & Metabolomics**	**01**
II		**Enzymology**	**15**
	2.1	**Introduction to enzymes:**	**06**
		a) General properties of enzymes b) How do enzymes accelerate reactions? c) Classification of enzymes d) Enzyme kinetics: Rate law for a simple catalyzed reaction, Michaelis-Menten equation and its derivation, other plots to determine velocity of reactions	

	2.2	**Modifying enzyme catalysis rates**	**05**
		a) Effect of temperature and pH b) Effect of Inhibitors- Reversible and irreversible, competitive, Non-competitive and uncompetitive inhibitors c) Allosteric effects in enzyme catalyzed reactions d) Multi-substrate reactions- Ordered, Random and ping-pong reactions e) Koshland- Nemethy and Filmer model **f)** Monod, Wyman and Chageux model	
	2.3	**Coenzymes& Co-factors:**	**04**
		a) Different types and reactions catalyzed by coenzymes (in tabular form) b) Water soluble coenzymes (NAD, Nicotinic acid) c) Fat soluble vitamins and their examples. **d)** Inorganic cofactors	
III		**Principles of Bioenergetics**	**15**
	3.1	**Bioenergetics & thermodynamics:**	**06**
		a) Energy transformations b) Thermodynamic quantities, standard –free energy **c)** Difference between ΔG & ΔGo‟	
	3.2	**ATP and it's role**	**05**
		a) Structure of ATP, phosphoryl group transfer and ATP b) Types of energy –rich compounds **c)** Multi-roles of ATP inorganic phosphoryl group donor	
	3.3	**Biological oxidation-reduction reactions**	**04**

References:

a) Principles of Biochemistry by Geoffery Zubay (1988) 4th Edition Wm.C. Brown Publishers
b) Outlines Of Biochemistry,5/E,Conn P.Stumpf, G.Bruening & R.Doi,John Wiley & Sons, New York 1995
c) Fundamentals of Enzymology: Cell and Molecular Biology of Catalytic Proteins 3rd Edition Nicholas Price and Lewis Stevens
d) Lehninger: Principles Of Biochemistry,4th Ed., D. Nelson & M. Cox, W.H.Freeman & Co., (LPE)
e) A biologist's Physical Chemistry by John Gareth Morris.
f) Concepts of Biochemistry, Rodney Boyer
g) Stanier, General microbiology 5th edition ,1987, Macmillan publication
h) Principles of Biochemistry by Robert Horton (2011) 5th Edition Pearson Publishers.

Course Code: RUSMIC 403

Course Title: APPLIED MICROBIOLOGY

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand and explain the significance of microbes in fermentation industry and compare the techniques used for their screening
CO 2	Compare different types of fermentations and fermentation processes used for industrial productions
CO 3	Exemplify components used in industrial fermentation media with an understanding of its role in the process
CO 4	Summarize the general principles of food spoilage by microorganisms and compare methods used for food preservation
CO 5	Execute experimental procedures for detection of microbes in food and dairy products and comment on its quality
CO 6	Recall the sources of microorganisms in milk and explain the significance of pasteurization techniques
CO7	Outline and analyze the manufacturing processes of different fermented dairy products
CO 8	Apply knowledge of contamination, preservation, and quality control in food and dairy product manufacturing industries

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 403		**APPLIED MICROBIOLOGY**	**2/45**
I		**Industrial Microbiology**	**15**
	1.1	**Strains of industrially important microorganisms**	**04**
		a) Desirable characteristics of an industrial strain **b)** Principles and methods of primary and secondary screening	
	1.2	**Types of fermentations:**	**02**
		a) Aerobic b) Anaerobic **c)** Solid state fermentation	
	1.3	**Types of fermentation processes:**	**02**
		a) Surface and Submerged b) Batch, continuous, fed-batch fermentation process	
	1.4	**Media for industrial fermentations**	**05**
		a) Production and Inoculum media b) Media components: - Carbon source, nitrogen source, amino acids and vitamins, minerals, water, buffers, antifoam agents, precursors, inhibitors and inducers	
	1.5	**Inoculum development**	**02**
II		**Food Microbiology**	**15**
	2.1	**Introduction:**	**01**
		Significance, food as a substrate and sources of microorganisms in food	
	2.2	**Intrinsic and extrinsic factors affecting the microbial growth in food**	**02**

	2.3	**General Principles of spoilage**	**04**
		Spoilage of fresh foods: fruits and vegetables, eggs, meat, poultry and seafood	
	2.4	**General principles of food preservation**	**04**
		(principle of each method and example of foods only) High temperature, low temperature, drying, radiations and food additives and preservatives (tabular representation), Asepsis, introduction to HACCP, Regulation	
	2.5	**Food borne diseases**	**1**
	2.6	**Methods of detection of microorganisms in food:**	**3**
		Overview of cultural, microscopic, physical, chemical and bioassay methods	
III		**Dairy Microbiology**	**15**
	3.1	**Milk- Definition, composition, sources of contamination of milk**	**2**
	3.2	**Pasteurization of milk** LTHT, HTST, UHT	**3**
	3.3	**Milk products: production and spoilage of:**	**7**
		a) Yoghurt b) Butter c) Cheese-Cheddar and Cottage cheese **d)** Fermented milks	
	3.4	**Quality control of milk**	**3**
		a) Rapid platform tests b) Microbiological analysis of milk : SPC, Coliform count, LPC, Psychrophiles, Thermophilic count, DRT	

References:

a) Fundamental Food Microbiology by Bibek Ray, Arun Bhunia (2007), 4th edition CRC Press
b) Food Microbiology by Frazier 5th ed (1971), McGraw-Hill Education.
c) Modern Food Microbiology by James Jay 6th ed(2000), Springer US.
d) Applied Dairy Microbiology by Marth & Steele(2001), CRC Press
e) BIS standards, FSSAI
f) Casida L. E., "Industrial Microbiology" 2009 Reprint, New Age International (P) Ltd,Publishers, New Delhi
g) Stanbury P. F., Whitaker A. & Hall--S. J., 1997, "Principles of Fermentation,Technology", 2nd Edition,Aditya Books Pvt. Ltd, New Delhi.
h) Prescott and Dunn's „"Industrial Microbiology"".1982 4th Edition, McMillan Publishers
i) H. A. Modi, 2009. „"Fermentation Technology"" Vol 2, Pointer Publications, India.
j) Milk and milk products. C. H. Eckles 1943 edition
k) Sukumar De, Outlines of dairy technology , 1st edition,1983, O.U.P
l) James Jay Frazier 5th. Ed Okafor Waites & Morgan

Course code	PRACTICALS	3 Credits
RUSMICP 401	**PRACTICAL-1**	
	1. Isolation of *Rhizobium* from root nodules 2. Demonstration of fungi and algae in lichens 3. Study of virulence factors – Enzymes – Streptokinase, Coagulase, Hemolysin, Lecithinase 4. Demonstration of biofilm formation by pathogens on catheters 5. Assignment on classical stages, signs and symptoms of any one microbial disease 6. Staining of blood film to demonstrate different types of leucocytes 7. Phagocytosis (Demonstration) 8. Study of plant microbe interactions: Screening for Auxin production (PGP from Rhizosphere) 9. Case studies and problems on Epidemiology 10. How to develop epidemiological surveys	
RUSMICP 402	**PRACTICAL-2**	
	1. Using KEGG, Ecocyc, metacyc, biocyc and Brenda for understanding metabolic networking 2. Qualitative detection of a. Amylase b. Lipase c. Protease d. DNase e. Catalase	

	f. Oxidase g. Carbohydrate fermentation h. Dehydrogenase 3. Production and purification of an enzyme 4. Assay of an enzyme and determination of enzyme units 5. Determination of km and Vmax of an enzyme 6. Effect of environment on enzyme activity: a. Effect of temperature b. Effect of pH c. Effect of enzyme concentration 7. Effect of inhibitors	
RUSMICP 403	**PRACTICAL-3**	
	1. Isolation of antibiotic producers from soil- Wilkin's overlay method. 2. Determination of microbial counts in food using dip slide technique (demonstration) 3. Isolation of food spoilage agent 4. Determination of TDT and TDP 5. Determination of Salt and sugar tolerance 6. Determination of MIC of a preservative 7. Visit to Food/Dairy industry 8. Rapid platform tests of raw and pasteurized milk. 9. Microbiological analysis of raw and pasteurized Milk. 10. Microbiological analysis of Butter, Cheese. 11. Surface and submerged fermentation.	

	12. Testing a packaged meat product for its microbial load.	

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks per paper

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks per paper

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be three questions each of 20 marks one on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1) A)	Any 3 out of 5	15	Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.2) A)	Any 3 out of 5	15	Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	
Q.3) A)	Any 3 out of 5	15	Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 &02	

	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 60 Marks

Particulars	Paper I	Paper II	Paper III
Journal	05	05	05
Experimental tasks	15	15	15
Total	**20**	**20**	**20**

B) External Examination: 60%- 90 Marks

Semester End Practical Examination:

Particulars	Paper I	Paper II	Paper III
Laboratory work	25	25	25
Spots/Quiz/Viva	05	05	05
Total	**30**	**30**	**30**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination & Marks Distribution Pattern
Semester IV

Course	401			402			403			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**300**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**150**

Course Code: RUSMIC 501

Course Title: Microbial Genetics

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand and differentiate between population and quantitative genetics and compare model organisms used in genetic studies.
CO 2	Summarize different natural plasmids and transposons present in prokaryotes and be able to compare and contrast between different plasmids.
CO 3	Understand the coherence of the molecular mechanisms involved in DNA replication and outline different enzymes and proteins associated with both prokaryotic and eukaryotic DNA replication
CO 4	Identify, interpret and classify mutations in DNA followed by mechanism of DNA repair
CO 5	Test the effect of mutagens on bacteria and identify mutants
CO 6	Solve and interpret problems based on mapping of bacterial genes using transformation, transduction and conjugation
CO 7	Retrieving basic concepts of homologous recombination and genetic exchange among prokaryotes

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 501		**MICROBIAL GENETICS**	**2.5/60**
I		**Branches of Genetics, Plasmids, Transposons**	**15**
	1.1	**Overview of branches of Genetics**	**04**
		a) Transmission, Molecular, b) Population Genetics: Hardy-Weinberg Law-principle and violation of assumptions (Mutation, Migration, Genetic Drift, Natural Selection) c) Quantitative Genetics: Characteristics, concept of Heritability, QTLs, Response to selection	
	1.2	**Model Organisms**	**03**
		a) Characteristics of a model organism b) Examples of select model organisms used in study: *E.coli,* Yeast, Mouse, *Caenorhabditis elegans*, *Arabidopsis thaliana*	
	1.3	**Plasmids**	**04**
		a) Physical nature b) Detection and isolation of plasmids c) Plasmid incompatibility and Plasmid curing d) Cell to cell transfer of plasmids e) Types of plasmids i. Resistance Plasmids ii. Plasmids encoding Toxins and other Virulence characteristics iii. col factor iv. Degradative plasmids	
	1.4	**Transposable elements in Prokaryotes**	**04**
		a) Insertion sequences b) Transposons i. Types ii. Structure and properties iii. Mechanism of transposition	

		iv. Transposon mutagenesis v. Integrons	
II		**DNA Replication**	**15**
	2.1	**Historical perspective**	**04**
		a) Conservative b) Dispersive c) Semi-conservative d) Bidirectional e) Semi-discontinuous DNA replication	
	2.2	**Prokaryotic DNA replication**	**`04**
		Details of molecular mechanism involved in Initiation, Elongation and Termination	
	2.3	**Enzymes and proteins associated with DNA replication**	**04**
		a) Primase b) Helicase c) Topoisomerase d) SSB e) DNA polymerases f) Ligases g) Ter and Tus proteins	
	2.4	**Eukaryotic DNA replication**	**02**
		a) Molecular details of DNA synthesis b) Replicating the ends of the chromosomes	
	2.5	**Rolling circle mode of replication**	**01**
III		**Mutation and Repair**	**15**
	3.1	**Mutation**	**10**
		a) Terminology: alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes b) Fluctuation test. c) Types of mutations: Point mutation, reverse mutation, suppressor mutation, frameshift mutation, conditional lethal mutation, base pair substitution, transition, transversion, missense mutation, nonsense mutation, silent mutation, neutral mutation, pleiotropic mutations. d) Causes of mutation: Natural/spontaneous mutation--replication error, depurination,	

		deamination. Induced mutation: principle and mechanism with illustrative diagrams for – i. Chemical mutagens- base analogues, nitrous acid, hydroxyl amine, intercalating agents and alkylating agents. ii. Physical mutagen iii. Biological mutagen (only examples) e) Ames test f) Detection of mutants	
	3.2	**DNA Repair**	**05**
		a) Mismatch repair b) Light repair c) Repair of alkylation damage d) Base excision repair e) Nucleotide excision repair f) SOS repair	
IV		**Genetic Exchange**	**15**
	4.1	**Gene transfer mechanisms in bacteria & homologous recombination**	
		a) Transformation i. Introduction and History ii. Types of transformation in prokaryotes—Natural transformation in *Streptococcus pneumoniae, Hemophilus influenzae* and *Bacillus subtilis* iii. Mapping of bacterial genes using transformation iv. Problems based on transformation.	**04**
		b) Conjugation i. Discovery of conjugation in bacteria ii. Properties of F plasmid/Sex factor iii. The conjugation machinery iv. Hfr strains, their formation and mechanism of conjugation v. F‘ factor, origin and behavior of F‘ strains, Sexduction. vi. Mapping of bacterial genes using conjugation (Wolman and Jacob experiment). vii. Problems based on conjugation	**05**
		c) Transduction i. Introduction and discovery ii. Generalized transduction iii. Use of Generalized transduction for mapping genes iv. Specialized transduction v. Problems based on transduction	**03**
	4.2	**Recombination in bacteria**	**03**

		a) General/Homologous recombination i. Molecular mechanism ii. Holliday model of recombination b) Site–specific recombination	

References:

a) Peter J. Russell, “Genetics-A molecular approach”, 2nd edition, 2006.
b) Benjamin A. Pierce, “Genetics a conceptual approachll”, 3rdedition, 2008, W. H. Freeman and company.
c) R. H. Tamarin, “Principles of genetics”, 2004, Tata McGraw Hill.
d) D, Nelson and M. Cox, “Lehninger‘s Principles of biochemistry” 4th edition,2005, Macmillan worth Publishers.
e) M.Madigan, J. Martinko, J.Parkar, “Brock Biology of microorganisms”, 12th edition, 2009, Pearson Education International.
f) Fairbanks and Anderson, “Genetics”,1999, Wadsworth Publishing Company.
g) Willey, Sherwood and Woolverton, Prescott’s Microbiology, 7th edition, 2013, International edition, McGraw Hill.
h) Robert Weaver, “Molecular biology”, 3rd edition, McGraw Hill international edition.
i) Nancy Trun and Janine Trempy, “Fundamental bacterial genetics”, 2004, Blackwell Publishing.
j) Snustad, Simmons, “Principles of genetics” 3rd edition, John Wiley & sons, Inc.
k) Stanier, Ingraham, “General Microbiology”,5th edition, Macmillan
l) Benjamin Lewin, “Genes IX”, Jones and Bartlett publishers.
m) JD Watson, Bake, Bell, Gann, Levine, Losick, “Molecular biology of the gene”, 5th edition, Person

Course Code: RUSMIC 502

Course Title: Medical Microbiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand modern alternatives to Koch's postulates
CO 2	Summarize the basic aspects of clinical and diagnostic microbiology and implement bacteriological investigations using good laboratory practices
CO 3	Understand, interpret and explain the coherence between pathogenesis mechanisms of microorganisms, clinical manifestation of disease and prophylactic measures of representative bacterial, fungal and parasitic infections in various organ systems
CO 4	Extrapolate the understanding of representative infections of skin, respiratory system, urinary tract, gastro intestinal tract central nervous system to other infections within the same system
CO 5	Given a few key clinical features, design and execute lab diagnostic procedures for any given pathological specimen and test antibiotic susceptibility of the isolated pathogen
CO6	Differentiate between the different classes of antibiotics on the basis of their mechanism of action
CO7	Attribute strategies through which microbes acquire anti-microbial resistance
CO8	Check and evaluate drugs/ antibiotics for their efficacy by demonstrating their action on microorganisms

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 502		**MEDICAL MICROBIOLOGY**	**2.5/60**
I		**Study of Infectious diseases-I**	**15**
	1.1	**Associating Microbes to disease**	**02**
		a) Koch's Postulate and modern alternatives to it b) Molecular Koch's postulates	
	1.2	**Introduction to Clinical and diagnostic Microbiology**	**05**
		a) Phases of diagnostic cycle- Pre analytic, analytic and post analytic b) Introduction to Molecular and immunological methods	
	1.3	**Study of Infectious Diseases-I** (With Emphasis on Characteristics of the Aetiological Agent, Pathogenesis & clinical features, Laboratory Diagnosis and Prevention)	**08**
		Respiratory diseases: a) Strep throat by *S. pyogenes* b) Diphtheria c) Common cold d) Tuberculosis *e)* Pneumonia caused by *K. pneumoniae*	
II		**Study of Infectious Diseases II** (With emphasis on cultural characteristics of the aetiological agent, pathogenesis, laboratory diagnosis and prevention)	**15**
	2.1	**Study of skin infections**	**05**
		a) Leprosy b) Pyogenic skin infections caused by *Pseudomonas, S. pyogenes* and *S. aureus*. c) Fungal infections- Oral Thrush, Dermatophytosis	
	2.2	**Study of gastrointestinal tract infections**	**08**
		a) Enteric fever- *Salmonella* b) Shigellosis	

		c) Infections due to pathogenic *E. coli* strains d) Rotavirus diarrhoea e) Dysentery due to *Entamoeba histolytica*	
	2.3	. **Study of urinary tract infections**	**02**
		a) Predisposing factors b) List of causative agents c) Pathogenesis and laboratory diagnosis	
III		**Study of Infectious Diseases III** (With emphasis on cultural characteristics of the aetiological agent, pathogenesis, laboratory diagnosis and prevention)	**15**
	3.1	**Study of vector-borne infections**	**03**
		a) Rickettsial diseases b) Malaria	
	3.2	**Study of sexually transmitted infectious diseases**	**07**
		a) Syphilis b) AIDS c) Gonorrhea	
	3.3	**Study of central nervous system infectious diseases**	**05**
		a) Tetanus b) Polio **c)** Meningococcal meningitis	
IV		**Chemotherapy of infectious agents**	**15**
	4.1	**Introduction to Chemotherapeutic agents**	**03**
		a) Attributes of an ideal chemotherapeutic agent and related definitions b) Selection and testing of antibiotics for bacterial isolates by Kirby-Bauer method and other assays (E-test & Checker Board Assay)	
	4.2	**Mode of action of antibiotics**	**08**
		a) Cell wall (Beta-lactams- Penicillin and Cephalosporins, Carbapenems) b) Cell Membrane (Polymyxin and Imidazole) c) Protein Synthesis Aminoglycosides (Streptomycin), Macrolide (Erythromycin), Tetracycline and Chloramphenicol d) Nucleic acid (Quinolones, Nalidixic acid, Rifamycin) e) Enzyme inhibitors (Sulfa drugs, Trimethoprim)	

	4.3	**List of common antibiotics** used for treating viral, fungal and parasitic diseases, New antibiotics	**01**
	4.4	**Mechanisms of drug resistance** Its evolution, pathways and origin	**03**

References:

a) Brenda Wilson, Abigail Salyer And Dixie Whitt, Bacterial Pathogenesis –A molecular approach 3rdEd ASM press 2011
b) Gary. W. Procop, Dierdre Church et al, Koneman's Color Atlas and Textbook of Diagnostic Microbiology, Seventh Ed, Walters Kluwer, 2017
c) Willey, Sherwood and Woolverton, Prescott's Microbiology, 9th edition, 2013, International edition, McGraw Hill.
d) Brooks, Carroll, et al, Jawetz, Melnick &Adelberg's Medical Microbiology, 26th Ed McGraw Hill Lange 2013
e) Ananthanarayan and Panicker's, Textbook of Microbiology, 10th edition, Ed by Reba Kanugo, Universities Press, 2017
f) Goering, Dockerel et al, Mim's Medical microbiology, 5th Ed 2013, Saunders

Course code	PRACTICALS	3 Credits
RUSMICP 501	**PRACTICAL 1**	
	1. UV survival curve – determination of exposure time leading to 90% reduction 2. Isolation of mutants using UV mutagenesis 3. Replica plate technique for selection & characterization of mutants – auxotroph & antibiotic resistant 4. Isolation and detection of plasmid DNA. 5. Preparation of competent cells and transformation 6. Demonstration of conjugation. 7. Assignment on sample collection, transport and processing of any one pathological sample 8. Rapid detection of infection in samples from CNS 9. Rapid Direct tests for identification of pathogens- a. Acid fast staining of *M. tuberculosis/ M.leprae*. b. Metachromatic granule staining for *C.diphtheriae* c. Catalase test d. Bile solubility test e. Slide coagulase test for *S.aureus* f. Spot indole test g. Oxidase test h. Modern methods for identification of pathogens. 10. Identification of isolates obtained from following samples by morphological, cultural and biochemical properties from- a. Nasal/ throat swabs (URT infection) b. Sputum (LRT infection) c. Skin swab/ pus (Skin infection) d. Identification of *Candida* species using the germ tube test and growth on HiChrom agar e. Stool (GI tract infection) f. Urine (UTI infection) 11. Demonstration of malarial parasite in blood film	

	12. Selection and testing of antibiotics using the Kirby-Bauer method 13. Determination of MIC of an antibiotic by E-test 14. Synergistic action of two drugs 15. Determination of MBC of an antibiotic. 16. Detection of β lactamase in *S.aureus.* 17. Role of plasmids in antibiotic resistance through curing of the plasmid	

Course Code: RUSMIC503

Course Title: Microbial Biochemistry Part I

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand the membrane architecture & critique the modes of solute transportation.
CO 2	Compare & contrast the mechanism of ATP synthesis in Prokaryotes & Eukaryotes.
CO 3	Summarize & differentiate the catabolic pathways of carbohydrates & deconstruct its amphibolic nature.
CO 4	Outline & evaluate the different fermentative pathways in bacteria.
CO 5	Paraphrase the anabolic pathways for carbohydrate synthesis.
CO 6	Organize the tally sheet of energetics for different catabolic substrates and solve problems based on these.
CO 7	Execute & evaluate the experimental aspects of metabolic reactions & differentiate organisms on the basis of their metabolic differences.

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 503		**MICROBIAL BIOCHEMISTRY PART I**	**2.5/60**
I		**Biological Membranes & Transport**	**15**
	1.1	**Composition and architecture of membrane**	**02**
		a) Lipids b) Integral & peripheral proteins & interactions with lipids c) Permeability and outer membrane- a barrier d) Aquaporins e) Mechanosensitive channels	
	1.2	**Methods of studying solute transport**	**02**
		a) Using whole cells b) Using Liposomes c) Using Proteoliposome	
	1.3	**Solute transport across membrane**	**08**
		a) Passive transport facilitated by membrane proteins. b) Transporters grouped into Superfamilies' ' c) Co transport across plasma membrane (Uniport, Antiport, Symport) d) Active transport & electrochemical gradient e) Ion gradient provides energy for secondary Active transport e.g. Lactose transport f) ATPases and transport g) ABC transporters e.g. Histidine transport h) Shock sensitive system – Role of binding proteins e.g. Maltose uptake i) Phosphotransferase system j) Schematic representation of various Membrane transport mechanisms in. *E. coli*	
	1.4	**Other examples of solute transport**	**03**
		a) Iron transport: A special problem b) Bacterial protein export c) Bacterial membrane fusion central to many biological processes	

II		**Bioenergetics and Bioluminescence**	**15**
	2.1	**Biochemical mechanism of generating ATP**	**01**
		a) Substrate level b) Oxidative c) Photo Phosphorylation	
	2.2	**Electron transport chain**	**03**
		a) Universal Electron acceptors that transfer Electrons to ETC. b) Carriers in ETC i. Hydrogen carriers – Flavoproteins, Quinones ii. Electron carriers-Iron sulphur proteins, Cytochromes c) Mitochondrial ETC i. Biochemical anatomy of mitochondria ii. Complexes in Mitochondrial ETC iii. Schematic representation of Mitochondrial ETC	
	2.3	**Prokaryotic ETC**	**03**
		a) Organization of electron carriers in bacteria b) Generalised electron transport pathway in bacteria c) Different terminal oxidases d) Branched bacterial ETC e) Pattern of electron flow in *E. coli*– aerobic an anaerobic f) Pattern of electron flow in *Azotobacter vinelandii*	
	2.4	**ATP synthesis**	**04**
		a) Explanation of terms – Proton motive force, Proton Coupling sites, P: O ratio, Redox potential b) Free energy released during electron transfer from to O_2. c) Chemiosmotic theory d) Structure & function of Mitochondrial ATP synthase (No Kinetics) e) Mechanism by Rotational catalysis f) Structure of bacterial ATP synthase g) Inhibitors of ETC, Inhibitors of ATPase, Uncouplers, Ionophores	
	2.5	**Other modes of generation of electrochemical energy**	**02**
		a) ATP hydrolysis b) Oxalate formate exchange	

		c) Product efflux, Definition- Lactate efflux d) Bacteriorhodopsin - Definition, Significance, Function as proton pump	
	2.6	**Bioluminescence**	**02**
		a) Brief survey of bioluminescent systems b) Biochemistry of light emission c) Schematic diagram d) Significance / Application	
III		**Methods of Studying Metabolism & Catabolism of Carbohydrates**	**15**
	3.1	**Experimental Analysis of metabolism**	**03**
		a) Goals of the study b) Levels of organization at which metabolism is studied. c) Metabolic probes d) Use of radioisotopes in biochemistry i. Pulse labelling ii. Assay & study of radio respirometry –to differentiate EMP & ED e) Use of biochemical mutants. f) Sequential induction technique	
	3.2	**Catabolism of Carbohydrates**	**12**
		a) Breakdown of polysaccharides – glycogen, starch, cellulose. b) Breakdown of oligosaccharides– lactose, maltose, sucrose, cellobiose c) Utilization of monosaccharides – fructose, Galactose. d) Major pathways- i. Glycolysis (EMP) & its regulation ii. HMP Pathway & Significance of the pathway iii. ED pathway, iv. TCA cycle, Significance & its regulation v. Anaplerotic reactions vi. Glyoxylate bypass, vii. Incomplete TCA in anaerobic bacteria viii. Amphibolic role of EMP and TCA cycle ix.Energetics of Glycolysis, ED and TCA- Balance sheet and efficiency calculation	
IV		**Fermentative Pathway & Anabolism of Carbohydrates**	**15**
	4.1	**Fermentative pathways** (With structures and enzymes)	**04**
		a) Lactic acid fermentation – i. Homofermentors	

		ii. Heterofermentors iii. Bifidobacterium pathway (Schematic) b) Alcohol fermentation i. by ED pathway in bacteria ii. by EMP in yeasts	
	4.2	**Other modes of fermentations in microorganisms**	**05**
		a) Mixed acid b) Butanediol c) Butyric acid d) Butanol-acetone e) Propionic acid (Acrylate pathway and succinate propionate pathway)	
	4.3	**Anabolism of Carbohydrates**	**06**
		a) General pattern of metabolism leading to synthesis of a cell from Glucose b) Gluconeogenesis c) Biosynthesis of Glycogen d) Biosynthesis of Peptidoglycan e) Role of carriers in synthesis of LPS and capsule	

References:

a) Stanier R. Y., Ingraham. J. L, Wheelis. M. L, Painter. P. R., General Microbiology, 5th edition, 1987, The Macmillan press Ltd.

b) Conn, E.E., P. K. Stumpf, G.Bruening and R. Y. Doi, Outlines of Biochemistry, 5th edition, 1987. John Wiley &Sons. New York.

c) Gottschalk, G., Bacterial Metabolism, 2nd edition, 1985, Springer Verlag.

d) White, D., The Physiology and Biochemistry of Prokaryotes, 3rd edition, 1995, Oxford University Press.

e) Nelson, D. L. and M.M. Cox, Lehninger, Principles of biochemistry. 4th edition, 2005, W. H. Freeman and Company.

f) Rose, A.H. Chemical Microbiology, 3rd edition, 1976, Butterworth-Heinemann.

g) Zubay, G. L, Principles of Biochemistry, 4th edition, 1996, Wm. C. Brown publishers

h) Mathews, C.K., K.E. van Holde, D.R. Appling, S.J. Anthony-Cahill, Biochemistry, 4th edition, 2012, Pearson.

i) Wilson and Walker, Principles & techniques of Biochemistry & Molecular Biology, 7th edition, 2010, Cambridge University Press.

j) Madigan, M.T. and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, 2006, Pearson Prentice Hall;

k) Cohen, G.N. , Microbial Biochemistry. 2nd edition, 2006, Springer.

Course Code: RUSMIC 504

Course Title: Bioprocess Technology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand and execute the process for isolation and strain improvement of industrially important microorganisms
CO 2	Outline the types and significance of sterilization process in fermentation industry
CO 3	Design the process of Inoculum development at various levels of scale-up
CO 4	Understand the assembly and working of typical fermenters and apply the knowledge to operate fermenters in microbiological industries
CO 5	Understand, attribute and apply methods of recovery and purification of fermentation products
CO 6	Recall, infer and apply methods in industrial effluent treatment and correlate it to environment protection
CO 7	Understand and use spectroscopic techniques in Biological analysis
CO 8	Recognize the significant role of different organizations in genesis of Intellectual Property Rights, categorize and use different types of intellectual property rights in protection of intangible properties

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 504		**BIOPROCESS TECHNOLOGY**	**2.5 /60**
I		**Upstream Processing**	**15**
	1.1	**Strains and Strain Improvement of industrial microorganisms**	**11**
		a) Isolation of industrially important microorganisms b) Improvement of industrial microorganisms i. Selection of induced mutants for primary metabolites ii. Isolation of induced mutants for secondary metabolites	
	1.2	**Sterilization**	**04**
		a) Introduction to the concept of media sterilization and Nabla factor b) Design and methods of batch sterilization c) Design and methods of continuous sterilization	
II		**Fermenter equipment and control**	**15**
	2.1	**Design of fermenter**	**05**
		a) Inoculum development b) Basics of fermenter i. Aseptic operation and containment ii. Body construction **iii.** Aeration and agitation c) Achievement and maintenance of aseptic condition i. Valves- function in general and examples ii. Steam Traps- function in general and examples	
	2.2	**Types of fermenters**	**05**
		a) Acetator b) Cavitator c) Tower fermenter d) Cylindro conical fermenters e) Air lift fermenters i. Outer loop fermenters ii. Inner loop fermenters f) Cyclone column	

		g) Packed tower (generator) h) Rotating disc fermenters i) Bubble cap fermenters	
	2.3	**Control of Variables**	**05**
		a) Types of variables b) Sensing and control of i. pH ii. Temperature iii. Dissolved oxygen iv. Flow measurement v. Pressure vi. Inlet/ Exit gas analysis vii. Foam sensing	
III		**Downstream processing**	**15**
	3.1	**Downstream processing**	**12**
		a. Recovery & Purification of fermentation products: i. Introduction ii. Precipitation iii. Filtration - theory, filter-aids, batch filters (Plate and frame filters), continuous filters (Rotary vacuum), iv. Centrifugation: flocculating agent, range of centrifuges - Basket, tubular bowl. b. Cell disruption methods: Physico-chemical. c. Liquid – Liquid extraction, Solvent recovery, d. Chromatography –Ion exchange &Adsorption e. Membrane processes – Ultrafiltration, reverse osmosis, liquid membranes. f. Drying, Crystallization, Whole broth processing	
	3.2	**Environmental aspects**	**3**
		a) Modern methods of effluent treatment b) Carbon Credits	
IV		**Bioinstrumentation And IPR**	**15**
	4.1	**Bioinstrumentation**	**8**
		Principles, working and applications of**:** a) Spectrophotometry (I. R) b) Atomic absorption (AAS) & Atomic Emission spectroscopy (Flame photometry) c) Mass Spectroscopy- MALDI ToF, ESI	
	4.2	**Intellectual Property Rights**	**7**
		a) Introduction to Intellectual Property	**1**

		b) Genesis of IPR - GATT, WTO, TRIPS, World Intellectual Property Organization (WIPO) c) Types of Intellectual Property – Patents, Copyright, Trademark, Trade secret, Plant varieties protection act, Industrial Designs, Geographical Indications	**3** **3**

References:

a) Casida L. E., "Industrial Microbiology'" (2009) Reprint, New Age International (P)Ltd, Publishers, New Delhi

b) Stanbury P. F., Whitaker A. & Hall S. J., (1997), "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.

c) H. A. Modi, (2009). _ 'Fermentation Technology ''Vols 1 & 2, Pointer Publications, India

d) Okafor Nduka (2007) _ 'Modern Industrial Microbiology and Biotechnology '', Science Publications Enfield, NH, USA.

e) G Y Shitole and Ram Sable (2012) Environmental Degradation Issues and Challenges (Research publication)

f) Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.

g) Principles and Techniques of Biochemistry and Molecular Biology by Wilson/Walker 7th Edition

h) Brian McNeil & Linda M. Harvey, Practical Fermentation Technology, John Wiley and Sons. Pvt. Ltd. (2008).

i) WIPO Publication No. 450(E) ISBN 978-92-805-1555-0
https://www.wipo.int/edocs/pubdocs/en/intproperty/450/wipo_pub_450.pdf

Course code	PRACTICALS	3 Credits
RUSMICP502	PRACTICAL 2	
	1. Isolation and detection of Mitochondria 2. Isolation and study of Bioluminescent organisms 3. Study of oxidative and fermentative metabolism 4. Carbohydrate fermentation tests 5. Mixed acid fermentations- Detection of organic acids by TLC 6. Study of Homo and Hetero fermentation in Lactic acid bacteria 7. Detection of enzyme phosphatase 8. Quantitative assay of Phosphatase 9. Stormy fermentation 10. Strip Plate Technique 11. Streak Plate Technique 12. Gradient plate technique for isolation of mutants. 13. Production and detection of vitamin B12 by bioautography. 14. Demonstration of IR spectroscopy and analysis of IR spectrum of one compound 15. Demonstration of GC-MS/ LC-MS	

Modality of Assessment:

Theory Examination Pattern:

A. Internal Assessment- 40%- 40 Marks per paper

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B. External Examination- 60%- 60 Marks per paper

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be **four** questions each of **15** marks on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Questions	Options	Marks	Total marks	Questions on
Q.1) A)	Any 2 out of 3	10		Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.2) A)	Any 2 out of 3	10		Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.3) A)	Any 2 out of 3	10		Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.4) A)	Any 2 out of 3	10		Unit IV
Q.4) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	

Practical Examination Pattern:

A. Internal Examination: 40%- 80 Marks

Practical	I		II	
Particulars	**Paper I**	**Paper II**	**Paper III**	**Paper IV**
Journal	05	05	05	05
Experimental tasks	15	15	15	15
Total	**20**	**20**	**20**	**20**

B. External Examination: 60%- 120 Marks

Semester End Practical Examination:

Particulars	Practical I	Practical II
Laboratory work	50	50
Spots/Quiz/Viva	10	10
Total	**60**	**60**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / In charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern
Semester V

Course	501			502			503			504			Grand Total
	In	Ex	Total	In	Ex	Total	In	Ex	Total	In	Ex	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**400**
Practical	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**200**

Course Code: RUSMIC 601

Course Title: Gene Manipulation, Bioinformatics, & Virology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand and explain the fundamentals of gene manipulation
CO 2	Implement bioinformatics tools for genetic analysis and structure building
CO 3	Correlate structure and function of important cell components of prokaryotic and eukaryotic cells
CO 4	Recalling and categorising various genes and proteins involved in functioning of prokaryotic and eukaryotic structures
CO 5	Summarizing the structure, classification, enumeration, cultivation and life cycle of viruses.
CO 6	Recognise and compare the commonly used terms like cancer, prions, viroids and their replication mechanisms
CO 7	Independently illustrate regulation of lytic and lysogenic pathway of lambda phage
CO 8	Test the presence of coliphages and execute experiments for their enumeration

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 601		**GENE MANIPULATION, BIOINFORMATICS, &VIROLOGY**	**2.5/60**
I		**Gene Manipulation**	**15**
	1.1	**Basic Principles of Gene Manipulation**	**12**
		a) Cutting and joining DNA: Restriction endonucleases, Ligases, Linkers and Adapters b) Cloning vectors: Characteristics of a good vector, Plasmid vectors, Bacteriophage λ, Expression vectors c) Cloning strategies: Genomic libraries, cDNA libraries, PCR	
	1.2	**Emerging techniques in Genome sciences**	**03**
		a) Microarray technologies b) Karyotyping c) CRISPR-based technologies and applications	
II		**Bioinformatics & Cell Biology**	**15**
	2.1	**Bioinformatics**	**06**
		a) Introduction i. Definition, aims, tasks and applications of Bioinformatics. ii. Overview of prominent Databases, tools and their uses iii. Importance, Types and classification of databases iv. Nucleic acid sequence databases- EMBL, GenBank, Ensembl v. Protein sequence databases-PIR, SWISS-PROT, TrEMBL vi. Protein structure databases: PDB, Cn3D. vii. Pathway analysis: KEGG. b) Applications: i. Transcriptome, Metabolomics, Pharmacogenomics,	

		ii. Phylogenetic analysis, Phylogenetic tree, Annotation, SNPs iii. Sequence alignment-- global v/s local alignment, FASTA file format, BLAST. iv. Genomics- structural, functional and comparative genomics. v. e. Proteomics- structural and functional proteomics.	
	2.2	**Cell Biology of Prokaryotes and Eukaryotes**	**09**
		a) Revision of structure and function of Cell wall, capsule, flagella and endospore of prokaryotes b) Cytoskeleton and cell motility i. Prokaryotic cytoskeleton: ftsZ and its role in cell division ii. Structure and function: Microtubules, Microfilaments, Intermediate filaments iii. Microtubular organelles – Cilia, Flagella and centrioles iv. Molecular motors: Myosins, Kinesins, Dyenin	
III		**Basic Virology**	**15**
	3.1	**Viral architecture**	**04**
		a) Capsid, viral genome and envelope b) Structure of TMV, T4, Influenza virus, HIV	
	3.2	**Viral classification**	**02**
	3.3	**The viral replication cycle**	**04**
		a) attachment, b) penetration, c) uncoating, d) types of viral genome and their replication, e) assembly, f) maturation and release	
	3.4	**Life cycle of viruses**	**05**
		a) T4 phage, b) TMV, c) Influenza Virus and d) HIV	
IV		**Advanced Virology**	**15**
	4.1	**Cultivation of viruses**	**05**

		a) Cell culture techniques, b) embryonated egg, c) laboratory animals, d) Cell culture methods: e) Equipment required for animal cell culture, f) Isolation of animal tissue	
	4.2	**Visualization and enumeration of virus particles**	**03**
		a) Measurement of infectious units i. Plaque assay ii. Fluorescent focus assay iii. Infectious centre assay iv. Transformation assay v. Endpoint dilution assay. b) Measurement of virus particles and their components i. Electron microscopy ii. Atomic force microscopy iii. Haemagglutination iii. Measurement of viral enzyme activity.	
	4.3	**Regulation of lytic and lysogenic pathway of lambda phage**	**03**
	4.4	**Role of viruses in cancer**	**02**
		a) Definitions, b) characteristics of cancer cell, c) cancer multi step process, d) Human DNA tumor viruses- i. EBV, ii. Kaposi's sarcoma virus, iii. Hepatitis B and C virus, iv. Papilloma Virus	
	4.5	**Prions and viroids**	**02**

References:

a) R. H. Tamarin, (2004), “Principles of genetics”, Tata McGraw Hill.
b) M. Madigan, J. Martinko, J. Parkar, (2009), “Brock Biology of microorganisms”, 12th ed., Pearson Education International.
c) Fairbanks and Anderson, (1999), “Genetics”, Wadsworth Publishing Company.
d) Prescott, Harley and Klein, “Microbiology” 7th edition McGraw Hill international edition.
e) Edward Wagner and Martinez Hewlett, (2005) “Basic Virology”, 2nd edition, Blackwell Publishing
f) Teri Shors, (2009), “Understanding viruses”, Jones and Bartlett publishers.
g) S.Ignacimuthu, (2005), “Basic Bioinformatics”, Narosa publishing house.
h) Robert Weaver, (2008), “Molecular biology”, 3rd ed. McGraw Hill international edition.
i) Primrose and Twyman, (2001), “Principles of gene manipulation and genomics”, 6thed, Blackwell Publishing
j) Arthur Lesk, (2009), “Introduction to Bioinformatics”, 3rd Edition, Oxford University Press
k) Snustad, Simmons, “Principles of genetics”, 3rdedn. John Wiley & sons, Inc.
l) Lodish, Scott.” Molecular cell biology,7th edn, Macmillan higher education, International ed.
m) Flint, Enquist, Racanillo and Skalka, “Principles of virology”, (2009)3rdedn. ASM press
n) T. K. Attwood & D. J. Parry-Smith, (2003), “Introduction to bioinformatics”, Pearson education
o) Benjamin Lewin, (2014) 9th edition, “Genes IX”, Jones and Bartlett publishers.
p) JD Watson, Baker (2004) 5thedn. “Molecular biology of the gene”, CSHL Press and Benjamin Cummings
q) Jonathan Pevsner, Bioinformatics and Functional Genomics, 3rd Edition, 2015, Wiley Blackwell
r) Jin Xiong, Essential Bioinformatics, 1st Edition, 2006, Cambridge University Press

Course Code: RUSMIC 602

Course Title: Immunology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Evaluate molecules for their antigenicity and explain role of haptens in elucidating molecular nature of antigens
CO 2	Outline mechanisms of antigen processing and presentation and the molecules involved thereof
CO 3	Understand the mechanisms of receptor-ligand interactions between cells involved in acquired as well as innate immune mechanisms
CO 4	Retrieve the process of T and B cell activation and proliferation in response to antigenic stimuli
CO 5	Summarize and compare the effector responses- Humoral Immunity & Cell Mediated Immunity
CO 6	Extrapolate the role of immune system in disease: Unregulated response- Hypersensitivity; exemplify the different types
CO 7	Understand the mechanism of Antigen-Antibody interaction & illustrate and execute immunological techniques for disease diagnosis
CO 8	Apply the concept of immunity for protection from disease by development of vaccine

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 602		**IMMUNOLOGY**	**2.5/60**
I		**Antigens and Antigen- antibody reactions**	**15**
	1.1	**Overview of innate and acquired immunity, cells and organs in immune responses**	**02**
	1.2	**Antigens**	**05**
		a) Immunogenicity versus antigenicity b) Factors that influence immunogenicity, Contribution of the biological system to immunogenicity c) Epitopes / antigen determinants (only concepts) d) Haptens and antigenicity e) Immunogenicity of some natural substances – native globular proteins, polysaccharides, lipids, nucleic acids Types of antigens – heterophile antigens, isophile antigens, sequestered antigens, super antigens, bacterial and viral antigens	
	1.3	**Antigen-Antibody reactions**	**08**
		a) Generation of Antibodies for experimental systems- Monoclonal antibodies b) Western Blotting c) Immunoprecipitation based assays d) Agglutination, passive agglutination, agglutination inhibition, e) Solid Phase assays- Radioimmunoassay (RIA), Enzyme immunoassays (EIA), f) Immunofluorescence, Immunohistochemistry g) Flow Cytometry, Fluorescence Activated Cell Sorting	
II		**Antigen presentation and Activation of Immune cells**	**15**
	2.1	**MHC complex and MHC molecules**	**03**

		a) Structure of class I, and class II molecules; class III molecules b) Peptide – MHC interaction	
	2.1	**Antigen processing and presentation**	**02**
		a) Antigen presentation- professional and nonprofessional cells b) Antigen processing and presentation	
	2.2	**Receptor Ligand interactions and activation in T cells**	**05**
		a) TcR, (alpha-beta, gamma-delta TcR), TcR-CD3 complex structure & functions, Accessory molecules. b) T cell activation, T cell differentiation, Subsets of T cells (TH1, TH2, TH17, T reg), Formation of Memory cells	
	2.3	**Receptor Ligand interactions and activation in B cells**	**05**
		a) B- cell receptors, Receptor associated molecules, receptor clustering. Antigen processing by B cells B cell activation and differentiation –Antigen recognition and presentation by B cells, Formation of germinal centres and memory cells. b) B-cell responses to Thymus dependent and independent antigens	
III		**Acquired Immune Responses and Innate Immune Mechanisms**	**15**
	3.1	**Cytokines**	**02**
		a) Properties, types and functions b) Cytokines secreted by Th1 and Th2 cells	
	3.2	**Humoral Response**	**04**
		a) Introduction of Humoral response, Primary and secondary responses b) Affinity maturation and somatic hyper mutation, Ig diversity, class switching	
	3.3	**Cell mediated effector response**	**03**
		a) Generation and target destruction by Cytotoxic T cells. b) Killing mechanism of NK cells.	

	3.4	**Innate Immune mechanisms**	**04**
		a) Role of PAMPs and PRRs in phagocytosis eg LPS b) Role of cytokines and chemokines in phagocytosis c) Induced proteins by PRR signalling d) Innate immunity and septic shock	
	3.5	**Interactions between Innate and Acquired immunity**	**02**
IV		**Vaccines, Immunohematology And Hypersensitivity**	**15**
	4.1	**Vaccines**	**05**
		a) Active and passive immunization b) Types of vaccines - Killed and attenuated vaccines, Whole organism vaccines, Purified macromolecules as vaccines, recombinant viral vector vaccines, DNA vaccines c) Use of adjuvants in vaccine d) New vaccine strategies, Ideal vaccine	
	4.2	**Immunohematology**	**05**
		a) Human blood group systems, ABO, secretors and non-secretors, Bombay Blood group b) Rhesus system and list of other blood group systems. c) Haemolytic disease of new born, Coombs test.	
	4.3	**Hypersensitivity**	**05**
		Coombs and Gell's classification Type I to Type IV hypersensitivity - Mechanism and manifestation.	

References:

a) Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, Kuby Immunology, 6th ed, W. H. Freeman & Company 2005

b) Oven, Punt, Stranford, Kuby Immunology,7th ed W.H. Freeman, 2013

c) Sulabha Pathak, Urmi Palan, Immunology: Essential and Fundamental, 3rd Ed, Anshan Ltd, 2011

d) Davis, Dulbecco, Eisen and Ginsberg, Microbiology, 4th ed, Lippincott Williams and Wilkins, 1990.

e) Fahim Halim Khan, The Elements of Immunology, Pearson Education, 2009

COURSE CODE	PRACTICALS	3 Credits
RUSMIC P601	**PRACTICAL 1**	
	1. Isolation of genomic DNA of *E. coli* and measurement of its concentration by UV-VIS. 2. Restriction digestion of plasmid DNA 3. Demonstration of PCR 4. Bioinformatics practical On Line Practical a. Visiting NCBI and EMBL websites & list services available, software tools available and databases maintained b. Visiting & exploring various databases mentioned in syllabus i. Using BLAST and FASTA for sequence analysis ii. Fish out homologs for given specific sequences (by teacher – decide sequence of some relevance to their syllabus and related to some biological problem e.g. evolution of a specific protein in bacteria, predicting function of unknown protein from a new organism based on its homology) iii. Six frame translation of given nucleotide sequence iv. Restriction analysis of given nucleotide sequence v. Pair-wise alignment and multiple alignment of a given protein sequences vi. Formation of phylogenetic tree 5. Enrichment of coliphages from sewage 6. Enumeration of phages- Phage assay (pilot & proper). 7. Demonstration of chick embryo inoculation 8. Antigen Preparation: 'O'& 'H' antigen preparation of Salmonella. Confirmation by slide agglutination 9. Electrophoresis of serum. 10. Demonstration of soluble antigens by precipitation reaction. 11. Immunodiagnostics- Dreyer's drop Widal test 12. Diagnosis of syphilis- TRUST antigen kit 13. Demonstration of ELISA 14. Blood grouping – Direct & Reverse typing 15. Major and minor compatibility test 16. Determination of Isoagglutinin titre 17. Coomb's Direct test	

Course Code: RUSMIC 603

Course Title: Microbial Biochemistry Part II

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Categorize lipids into different classes based on their structure
CO 2	Map the steps in the biochemical pathway for metabolism of lipids
CO 3	Outline pathways for biochemical synthesis, degradation and recycling of nucleic acids
CO 4	Explain mechanisms of catabolism of protein and synthesis of amino acid synthesis in the cell
CO 5	Compare and contrast between various levels of metabolic regulation
CO 6	Explain process of prokaryotic photosynthesis and attribute it to photosynthetic pigments, photochemical apparatus and light and dark reactions
CO 7	Compare and contrast metabolism of different inorganic compounds and outline the concept of Lithotrophy
CO 8	Execute and implement enzyme assays and testing of metabolic processes

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 603		MICROBIAL BIOCHEMISTRY PART II	2.5/60
I		Lipid Metabolism & Catabolism Of Hydrocarbons	15
	1.1	General introduction to Lipids	02
		a) Lipids and their functions b) Action of lipases on triglycerides /tripalmitate c) Phospholipids and their properties d) Common phosphoglycerides in bacteria	
	1.2	Catabolism of Lipids	05
		a) Oxidation of saturated fatty acid- β oxidation pathway, Energetics of β oxidation of Palmitic acid b) Oxidation of propionic acid. c) Degradation of poly beta hydroxy butyrate	
	1.3	Anabolism of Lipids	05
		a) Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid) b) Biosynthesis of phosphoglycerides in bacteria c) Biosynthesis of PHB	
	1.4	Catabolism of aliphatic hydrocarbons	03
		a) Oxidation of saturated aliphatic hydrocarbon (n-alkane) b) Omega oxidation pathway- c) Pathway in Corynebacterium and yeast d) Pathway in Pseudomonas	
II		Metabolism Of Proteins And Nucleic Acids	15
	2.1	Protein catabolism	05
		a) Enzymatic degradation of proteins b) Metabolic fate of amino acids (schematic only c) Metabolism of single amino acids – i. Deamination reactions ii. Decarboxylation iii. Transamination	

		e) Fermentation of single amino acid -Glutamic acid by Clostridium f) Fermentation of pair of amino acids -Stickland reaction	
	2.2	**Amino acid synthesis**	**04**
		a) Schematic representation of amino acid families b) Synthesis of amino acids of Aspartate family	
	2.3	**Nucleic acid Catabolism**	**03**
		a) Degradation of purine nucleotides up to uric acid formation b) Recycling of purine and pyrimidine nucleotides by salvage pathway	
	2.4	**Anabolism of Nucleic Acids**	**03**
		a) Metabolic origin of atoms in purine and pyrimidine ring b) Biosynthesis of pyrimidine nucleotides. c) Biosynthesis of purine nucleotides. d) Formation of deoxyribonucleotides. e) Synthesis of nucleotide diphosphates and triphosphates. f) Role of nucleotides (high energy triphosphates)	
III		**Metabolic Regulation**	**15**
	3.1	**Overview and major modes of regulation**	**01**
		Examples of cellular control mechanism acting at various levels of metabolism (tabulation only)	
	3.2	**Allosteric proteins**	**04**
		a) Definition b) Allosteric enzymes - Role of allosteric enzymes using ATCase as example (no kinetic study) c) Regulatory allosteric proteins i. Interaction of proteins with DNA ii. Structure of DNA Binding proteins iii. Examples - Lac repressor, Trp repressor, CAP protein iv. Definition and examples of alarmones	
	3.3	**Regulation of gene expression (Transcription)**	**06**
		a) Introduction to operon model b) Common patterns of regulation of transcription – General concept of positive and negative	

		regulation of operons i. Lac operon - Mechanism of regulation - Induction - Catabolite repression ii Trp operon - End Product Repression - Attenuation c) Regulation of gene expression i. Multiple Sigma Factors ii. Riboswitches	
	3.4	**Regulation of enzyme activity (Post translational regulation)**	**04**
		a) End-Product Inhibition and Mechanism of End Product Inhibition in branched pathways with examples i. Isofunctional enzymes ii. Concerted feedback inhibition iii. Sequential feedback inhibition iv. Cumulative Feedback inhibition v. Combined activation and inhibition b) Covalent modifications of enzymes i. General examples without structure ii. Monocyclic cascade &inter-convertible enzyme definition iii. Glutamine synthetase system of *E .coli* iv. Regulation by proteolytic cleavage	
		Prokaryotic Photosynthesis & Inorganic Metabolism	**15**
	4.1	**Prokaryotic photosynthesis**	**09**
IV		a) Early studies on photosynthesis i. Light and dark reactions ii. Bacterial photosynthesis iii. Hill reaction b) Phototrophic prokaryotes -Oxygenic, Anoxy phototrophs examples only c) Photosynthetic pigments d) Location of photochemical apparatus e) Photophosphorylation f) Light reactions in i. Purple photosynthetic bacteria ii. Green sulphur bacteria ii. Cyanobacteria (with details) g) Dark reaction i. Calvin Benson cycle ii. Reductive TCA	
	4.2	**Inorganic Metabolism**	**06**
		a) Assimilatory pathways-	03

		i. Assimilation of nitrate, ii. Ammonia fixation – Glutamate dehydrogenase, iii. Glutamine synthetase, GS-GOGAT, Carbamoyl phosphate synthetase iv. Biological nitrogen fixation (Mechanism for N2 fixation and protection of nitrogenase) v. Assimilation of sulphate b) Dissimilatory pathways- i. Nitrate as an electron acceptor (Denitrification in *Paracoccus denitrificans*) ii. Sulphate as an electron acceptor c) Lithotrophy– Enlist organisms and products formed oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron.	2 1

References:

a) Stanier, R. Y., M. Doudoroff and E. A. Adelberg. General Microbiology, 5th edition, The Macmillan press Ltd

b) Conn, E.E., P. K. Stumpf, G. Bruening and R. Y. Doi. 1987. Outlines of Biochemistry, 5th edition, 1987. John Wiley & Sons. New York.

c) Gottschalk, G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag

d) White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press

e) Nelson, D. L. and M.M. Cox (2005), Lehninger, Principles of biochemistry. 4th edition, W. H. Freeman and Company.

f) Salle, A.J. Fundamental Principles of Bacteriology, 7thedn McGraw Hill Book Co.

g) Cohen, G.N. (2011). Microbial Biochemistry. 2ndedn, Springer

h) Madigan, M.T. and J.M. Martinko 2006. Brock Biology of Microorganisms. Pearson Prentice Hall;

i) Biochemistry 3rd edition, Mathew, Van Holde and Ahern, Pearson Education

j) Zubay, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers

k) Principles of Biochemistry, Lehninger, 5thednW. H. Freeman and Company

Course Code: RUSMIC 604

Course Title: Industrial Microbiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
CO 1	Understand and outline the processes of fermentation for the bulk production of primary and secondary metabolites and summarize the significance of each step
CO 2	Outline the production of commercially important fermentation products like fermented foods, alcoholic beverages, SCP, probiotics etc.
CO 3	Extrapolate the examples studied to design and execute conventional fermentation processes and be able to collaborate to set up an enterprise
CO 4	Explain the principles underlying Bioassays and differentiate and compare the methods of Biological assays
CO 5	Test and evaluate activity of fermentation products using microbiological assays
CO 6	Summarize factors responsible for contamination during production of sterile products, execute preventive measures against contamination
CO 7	Evaluate effectiveness of sterilization procedures and assess the Microbiological Quality of pharmaceutical products
CO 8	Outline the salient features of quality management and Good Manufacturing Practices

DETAILED SYLLABUS

Course Code	Unit	Course/ Unit Title	Credits/ Lectures
RUSMIC 604		**INDUSTRIAL MICROBIOLOGY**	**2.5 /60**
I		**Industrial Fermentations: I**	**15**
		a) Types of alcoholic beverage. b) Beer –Ale and Lager c) Wine –Red and white & Champagne d) Vinegar (acetator& Generator) e) Bioethanol production- -From feedstock to fermentable sugars - *Zymomonas mobilis* as an alternate ethanol producer f) Acetone Butanol Fermentation	**1** **3** **4** **2** **3** **2**
II		**Industrial Fermentations: II**	**15**
	2.1	**Production of secondary metabolites-** Antibiotics- Penicillin& Semisynthetic Penicillins	**04**
	2.2	**Production of primary metabolites-** a) Vitamin B_{12} from *Propionibacterium* & *Pseudomonas* b) Amino acids- Methods for manufacture, Glutamic Acid (direct) c) Organic acids- Citric acid d) Enzymes- Uses of enzymes in industry, Production of Fungal amylase by solid substrate fermentation, Stabilization of enzymes- Immobilization techniques e) Biotransformation of steroids	 **03** **01** **02** **04** **01**
III		**Industrial Fermentations: III**	**15**
	3.1	a) Mushroom cultivation b) SCP- Substrates used, Organisms and safety c) Fermented foods- Bread, Fermented cassava, Kombucha tea d) Mold modified foods- Types (list only), Production of Soya sauce e) Lactic acid starter cultures, Probiotics, Prebiotics and Synbiotics	**03** **03** **03** **02** **04**
IV		**Bioassays & Quality Assurance**	**15**

	4.1	**Bioassays**	**05**
		a) Comparison of Chemical and Biological assays b) Microbiological assays- Test organisms, types of assay methods and factors affecting. **c)** Modern methods for assay of fermentation products	
	4.2	**QA, QC, GMP**	**07**
		a) Definitions- Manufacture, Quality, Quality Control, In-Process Control, Quality Assurance, Good Manufacturing Practices. b) Chemicals & Pharmaceutical production: The five variables, Raw materials, in process Items, Finished Products, Labels and Labelling, Packaging materials, Documentation, Regulations. c) Control of Microbial contamination during manufacture: Premises and contamination control Manufacture of sterile products, Clean and Aseptic Area, Important publications related to QA	
	4.3	**Sterilization Control and Sterility Assurance**	**03**
		a) Bio-burden determinations b) Environmental monitoring c) Sterilization Monitors – Physical, Chemical and Biological indicators d) Sterility Testing	

References:

a) Crueger W. and Crueger A. (2000) "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.

b) Casida L. E., "Industrial Microbiology 2009 Reprint, New Age International (P) Ltd, Publishers, New Delhi

c) H. A. Modi, 2009. 'Fermentation Technology ''Vol: 1 & 2, Pointer Publications, India

d) Prescott and Dunn's 'Industrial Microbiology' (1982) 4th Edition, McMillan Publishers

e) Hugo & Russell's, Pharmaceutical Microbiology Blackwell Science, Seventh Edition

f) Peppler, H. J. and Perlman, D. (1979), "Microbial Technology''. Vol 1 & 2, Academic Press.

g) Michael J. Waites, 2001 —Industrial Microbiology: An Introduction, Blackwell Science Publications

h) Naduka Okafor, —Modern Industrial Microbiology, Science Publications, 2007

i) R. W. Hutkins, "Microbiology and Technology of Fermented Foods (2006) Blackwell Publications p067-105

j) https://www.dairyscience.info/index.php/cheese-starters/49-cheese-starters.html
k) Marth and Steele, “Applied Dairy Microbiology”, Lactic acid starter cultures, (2001)
l) Probiotics and Prebiotics https://www.spg.pt/wp-content/uploads/2015/11/2011-Probiotics_FINAL_20110116.pdf

COURSE CODE	PRACTICALS	3 Credits
RUSMICP602	**Practical Based on 603**	
	1. Qualitative detection of Lipase 2. Estimation of proteins by Lowry's method 3. Qualitative detection of Protease 4. Assay of enzyme Protease 5. Study the breakdown of amino acids – Lysine decarboxylase and Deaminase activity 6. Estimation of uric acid 7. To study catabolite repression 8. Study of Hill reaction 9. Study of photosynthesis in microalgae 10. Study of Lithotrophs – Nitrification 11. Alcohol tolerance for yeast. 12. Sugar tolerance for yeast. 13. Inoculum Development for alcohol fermentation 14. Alcohol fermentation.: -Efficiency of fermentation 15. Chemical estimation –Sugar by Cole's Ferricyanide method 16. Chemical estimation –Alcohol Estimation-Dichromate method 17. GC demonstration of ethanol 18. Production of fungal amylase using solid substrate fermentation 19. Immobilization of yeast invertase 20. Mushroom cultivation 21. Production of Spirulina SCP 22. Bioassay of an antibiotic Ampicillin 23. Bioassay of Cyanocobalamin. 24. Chemical assay of Ampicillin 25. Sterility testing of water for injection.	

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Modality of Assessment:

Theory Examination Pattern:

A. Internal Assessment- 40%- 40 Marks per paper

Sr No	Evaluation type	Marks
1	One Assignment/Case study/Project/ Presentation	20
2	One class Test (multiple choice questions / objective)	20
	TOTAL	**40**

B. External Examination- 60%- 60 Marks per paper

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be **four** questions each of **15** marks on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Questions	Options	Marks	Total marks	Questions on
Q.1) A)	Any 2 out of 3	10		Unit I
Q.1) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.2) A)	Any 2 out of 3	10		Unit II
Q.2) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.3) A)	Any 2 out of 3	10		Unit III
Q.3) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	
Q.4) A)	Any 2 out of 3	10		Unit IV
Q.4) B)	Any 1 set out of 2 (i & ii or i & ii)	03 & 02	15	

Practical Examination Pattern:

A. Internal Examination: 40%- 80 Marks

Practical	I		II	
Particulars	**Paper I**	**Paper II**	**Paper III**	**Paper IV**
Journal	05	05	05	05
Experimental tasks	15	15	15	15
Total	**20**	**20**	**20**	**20**

B. External Examination: 60%- 120 Marks

Semester End Practical Examination:

Particulars	Practical I	Practical II
Laboratory work	50	50
Spots/Quiz/Viva	10	10
Total	**60**	**60**

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.
In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / In charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern
Semester VI

Course	601			602			603			604			Grand Total
	In	Ex	Total	In	Ex	Total	In	Ex	Total	In	Ex	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practical	20	30	50	20	30	50	20	30	50	20	30	50	200