

AC 6-6-12

Item No. 4.115

# **UNIVERSITY OF MUMBAI**



## **Syllabus for the M.Sc. Semester I and Semester II**

**Program: M.Sc.**

**Course: Bio-Chemistry**

(Credit Based Semester and Grading System with  
effect from the academic year 2012–2013)

## SYLLABUS OF M.Sc. CREDIT SYSTEM IN BIOCHEMISTRY

TO BE BROUGHT INTO FORCE FROM THE ACADEMIC YEARS 2012-2013

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### Objectives

1. To Strengthen the base in fundamental aspects of Biochemistry viz. Bio-organic and Biophysical Chemistry, Instrumentation, Metabolism, Medical/Clinical Chemistry and Human Nutrition and Dietetics.
2. To develop broad perspective with respect to the advanced areas of Biochemistry viz. Genetics and Molecular Biology, Immunology, Recombinant DNA Techniques and Industrial Biochemistry.
3. To familiarize with research methodology to help students develop research aptitude through research projects.
4. To create awareness in Biostatistics for applicability to research.
5. To open up new vistas in the fast emerging and developing areas of Bio-informatics and applications of computers in Bio-chemistry.
6. To sharpen practical skills in performing experiments involving latest protocols.
7. To augment experimental expertise by handling modern instruments.
8. To train young minds for gainful employment in industry, research-oriented career and qualifying examinations like NET and SET.
9. To develop scientific temper and interest by exposure through Internet. Computers, various data bases and industrial visits and study/educational tours.
10. To provide platform for interaction with scientists at research centres/ universities/ industries including internship for training/ summer project for 03 to 06 months and also for the gainful employment.

**Scheme for Theory Paper  
(4 Credits per Paper per Semester)**

**M.Sc. Semester I**

<b>Course Code</b>	<b>Topic Headings</b>	<b>Credits</b>
PSBCH-101	Advanced Bio-organic Chemistry	4
PSBCH-102	Advanced Instrumentation and Analytical Techniques	4
PSBCH-103	Industrial Biochemistry	4
PSBCH-104	Research Methodology, Bio-statistics & Bio-informatics	4

**M.Sc. Semester II**

<b>Course Code</b>	<b>Topic Headings</b>	<b>Credits</b>
PSBCH-201	Advanced Bio-organic Chemistry	4
PSBCH-202	Advanced Instrumentation and Analytical Techniques	4
PSBCH-203	Industrial Biochemistry	4
PSBCH-204	Research Methodology, Bio-statistics & Bio-informatics	4

**M.Sc. Semester III**

<b>Course Code</b>	<b>Topic Headings</b>	<b>Credits</b>
PSBCH-301	Advanced Genetics	4
PSBCH-302	Advanced Immunology	4
PSBCH-303	Advanced Metabolism	4
PSBCH-304	Clinical and Pharmaceutical Biochemistry, Human Nutrition and Dietetics	4

**M.Sc. Semester IV**

<b>Course Code</b>	<b>Topic Headings</b>	<b>Credits</b>
PSBCH-401	Advanced Genetics	4
PSBCH-402	Advanced Immunology	4
PSBCH-403	Advanced Metabolism	4
PSBCH-404	Clinical and Pharmaceutical Biochemistry, Human Nutrition and Dietetics	4

## Semester-wise Details of Unit I to IV in each theory paper

### SEMESTER I

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
<b>PSBCH101</b>	<b>I</b>	Biochemical Basic of Evolution	<b>4</b>	<b>1</b>
	<b>II</b>	Bioenergetics		<b>1</b>
	<b>III</b>	Protein chemistry & Enzymology		<b>1</b>
	<b>IV</b>	Membrane Biochemistry & cell signalling		<b>1</b>
<b>PSBCH102</b>	<b>I</b>	Colligative properties	<b>4</b>	<b>1</b>
	<b>II</b>	Acids, Bases & Buffers		<b>1</b>
	<b>III</b>	Microscopy and Radioactive Techniques		<b>1</b>
	<b>IV</b>	Spectroscopic Techniques		<b>1</b>
<b>PSBCH103</b>	<b>I</b>	Bioprocess Technology & Fermentation	<b>4</b>	<b>1</b>
	<b>II</b>	Technologies in cell & Tissue culture & Marine Biotechnology		<b>1</b>
	<b>III</b>	Techniques in Food Preservation		<b>1</b>
	<b>IV</b>	Industrial Proteins & Enzymes		<b>1</b>
<b>PSBCH 104</b>	<b>I</b>	What is Research? Research Design	<b>4</b>	<b>1</b>
	<b>II</b>	Presentation and Processing of Data		<b>1</b>
	<b>III</b>	Analysis of Data		<b>1</b>
	<b>IV</b>	Bioinformatics - I		<b>1</b>

<b>PSBCHP101</b>	Colorimetry, Volumetry, Enzymology, Buffers, Microscopy	<b>2</b>	<b>4</b>
<b>PSBCHP102</b>	Biochemical, Clinical Analysis	<b>2</b>	<b>4</b>
<b>PSBCHP103</b>	Isolations, Preparations, Extraction & assay	<b>2</b>	<b>4</b>
<b>PSBCHP104</b>	Research Methodology, Biostatistics & Bioinformatics	<b>2</b>	<b>4</b>

## SEMESTER II

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
<b>PSBCH201</b>	<b>I</b>	Plant Biochemistry	<b>4</b>	<b>1</b>
	<b>II</b>	Endocrinology		<b>1</b>
	<b>III</b>	Biochemistry of Tissues		<b>1</b>
	<b>IV</b>	Bioluminescence and Unusual Biomolecules		<b>1</b>
<b>PSBCH202</b>	<b>I</b>	Centrifugation	<b>4</b>	<b>1</b>
	<b>II</b>	Chromatography		
	<b>III</b>	Electrophoresis&sequencing Techniques		
	<b>IV</b>	Special Instrumental Methods of Analysis		
<b>PSBCH203</b>	<b>I</b>	Carbohydrates of Industrial Importance	<b>4</b>	<b>1</b>
	<b>II</b>	Lipids of Industrial Importance		<b>1</b>
	<b>III</b>	Environmental Biotechnology		<b>1</b>
	<b>IV</b>	Nano-biotechnology& other topics		<b>1</b>
<b>PSBCH204</b>	<b>I</b>	Report writing & Presentation	<b>4</b>	<b>1</b>
	<b>II</b>	Sampling and Estimating Population Parameters		<b>1</b>
	<b>III</b>	Chi-square Test& Other Topics		<b>1</b>
	<b>IV</b>	Bioinformatics II		

<b>PSBCHP201</b>	Chromatography and electrophoresis techniques.	<b>2</b>	<b>4</b>
<b>PSBCHP202</b>	Clinical Estimations	<b>2</b>	<b>4</b>
<b>PSBCHP203</b>	Extraction, Isolation And Partial Purification Techniques	<b>2</b>	<b>4</b>
<b>PSBCHP204</b>	Biostatistics & Bioinformatics	<b>2</b>	<b>4</b>

## Detail Theory Syllabus

### Semester I

Course Code	Title	Credits
PSBCH101	Advanced Bioorganic Chemistry	4
<b>Unit I:</b> <b>1.1 <u>Biochemical Basis of Evolution</u></b> 1.1.1 Theory of chemical evolution and spontaneous origin of molecular level 1.1.2 Opar in's Hypothesis, Miller Experiment, Smith's Model, RNA first model 1.1.3 Process or Origin of life of Eukaryotes, Molecular Evolution os Proteins.	<b>Number of Lectures</b>  <b>15</b>	
<b>Unit II:</b> <b>2.1 <u>Bio-energetics</u></b> 2.1.1 Laws of thermodynamics as applied to biological systems, enthalpy, entropy, free energy, standard free energy 2.1.2 Role of High Energy phosphates in Bio-energetics and energy capture, Theories of ATP Biosynthesis 2.1.3 Electron Transport Chain in Plants, Eukaryotes and Prokaryotes, Significance or Redox potentials, Mechanism of Oxidative Phosphorylation. 2.1.4 Numerical problems based on the above	<b>15</b>	
<b>Unit : III</b> <b>3.1 <u>Protein Chemistry</u></b>  3.1.1 Polypeptide backbone, covalent and non-covalent interactions, end-group analysis by chemical and enzymatic methods, Conformation, Configuration 3.1.2 Details of 1 <sup>0</sup> , 2 <sup>0</sup> , 3 <sup>0</sup> and 4 <sup>0</sup> structures, problems based on determination of 1 <sup>0</sup> structure, Ramchandran Plot, structure-function relation of protein (Ex. Haemoglobin) 3.1.3 Chemical modification and cross-linking in proteins, dynamic properties and mechanisms of protein folding	<b>06</b>	

<p><b>3.2 <u>Enzymology</u></b></p> <p>3.2.1 IUB/EC Enzymes classification active site identification and conformation</p> <p>3.2.2 Michaelis-Menten Kinetics of monosubstrate enzyme reaction, LB Plot, EinsethalCornish Bowden Plots</p> <p>3.2.3 Mechanism of Enzyme Action for Acid –Base Electrostatic and Covalent Catalysis (Ex. Chymotrypsin, Carboxypeptidase-A)</p> <p>3.2.4 Enzyme Inhibition-Reversible competitive, non-competitive, uncompetitive, Partial, Mixed, Allosteric Irreversible and Feedback Inhibition.</p> <p>3.2.5 Allosteric Enzymes-Kinetics Significance of Sigmoidal Behaviour, Role in Metabolic Regulation.</p> <p>3.2.6 Iso-enzymes – separation and significance</p> <p>3.2.7 Enzyme Reaction in non-aqueous Media.</p> <p>3.2.8 Enzyme Immobilization and Applications</p> <p>3.2.9 Clinical Enzymology- Enzymes as therapeutic agents, diagnostic tools and laboratory agents.</p>	<p><b>09</b></p>
<p><b>Unit : IV</b></p>	
<p><b>4.1 <u>Membrane Biochemistry</u></b></p> <p>4.1.1 Molecular constituents of Membrane and supra-molecular architecture</p> <p>4.1.2 Principles and Mechanism of Diffusion and Passive, Active &amp; facilitated Transport</p> <p>4.1.3 Artificial Membranes (Liposomes) in Drug Delivery, Kinetics of Super-molecular Membrane Assembly (Viruses and Ribosomes)</p>	<p><b>07</b></p>
<p><b>4.2 <u>Cell Signalling</u></b></p> <p>4.2.1 Classes of Cell Receptors, Molecular Mechanism of Cell Signalling via G-protein linked Cell Surface Receptors, Trimeric G-proteins and their regulatory mechanism, Role of Ca<sup>++</sup> as an intracellular signal, Ca<sup>++</sup> / Calmodulin dependent protein kinase, cAMP- Ca<sup>++</sup> Pathway</p> <p>4.2.2 Signalling via enzyme-linked cell surface receptor, Ras – Proteins and their role in signalling cascade.</p> <p>4.2.3 Programmed Cell Death (apoptosis) involving onco-genes and tumour suppressor genes</p>	<p><b>08</b></p>

Course Code	Title	Credits
<b>PSBCH102</b>	<b>Advanced Instrumentation and Analytical Techniques</b>	4
<b>Unit I:</b> <b>1.1 Colligative Properties</b> 1.1.1 Definitions, Factors affecting and Physiological Applications of Osmosis, Adsorption, Colloids, Surface Tension and Viscosity 1.1.2 Numerical Problems based on above concepts		<b>Number of Lectures 15</b>
<b>Unit II:</b> <b>2.1. Acid, Bases and Buffers</b> 2.1.1 Ionization, Dissociation, Acidity, Basicity theories of Acid and Bases, Strength of Acids and Bases, Acid-Base Equilibrium in Aqueous and Non-aqueous media. 2.1.2 pH, pH-dependent functions and structures of bio-molecules, Henderson –Hasselbach Equation, Use of Indicators, Buffers, Amino Acid titrations, Formal Titration 2.1.3 Numerical Problems based on above concepts		<b>15</b>
<b>Unit : III</b> <b>3.1 Microscopy</b> 3.1.1 Basic principles, instrumentation and application of Phase, ultraviolet and interference microscope and Fluorescence microscopy 3.1.2 Electron microscope – scanning emission microscopy, transmission emission microscopy 3.1.3 Confocal microscopy and Atomic force microscopy <b>3.1 Radioisotope Techniques</b> 3.2.1 Nature of radioactivity & its detection and measurements of Radioactivity, GM Counter, Scintillation Counter, Pulse Height Analyser.. 3.2.2 Isotope Dilution, Analysis, Autoradiography, Application of Radioisotopes in Biological Science 3.2.3 Safety Measures in Handling Isotopes.		<b>07</b>  <b>08</b>
<b>Unit : IV</b> <b>4.1 Spectroscopic Techniques</b> 4.1.1 Beer-Lamberts Law, Its verifications and Deviations, Concept of Absorptions, Transmission, Scattering, Phosphorescence, Fluorescence, Luminescence, Diffraction Spectra 4.1.2 Principle Instrumentation, working and application of – U V, Visible and IR Spectroscopy, Turbidometry and Nephelometry.		<b>15</b>



4.1.3	Principle, instrumentation, working and application of – Spectrofluorimetry, Flame Spectrophotometry, Atomic Absorption Spectrometry, Luminometry.	
4.1.4	Principle, instrumentation, working and application of- Nuclear Magnetic Resonance(NMR), Electron Spin Resonance (ESR), Mossbauer Spectroscopy, Matrix Assisted LASER Desorption, ionization, Time of Flight-Mass Spectroscopy (MALDI-TOF-MS)	
4.1.5	X-Ray Diffraction Spectra, Optical Rotatory Dispersion, (ORD), Circular Dichroism (CD)	
4.1.6	LASER- Principle, applications in Medicine and Biological Sciences	

Course Code	Title	Credits
<b>PSBCH103</b>	<b>Industrial Biochemistry</b>	<b>4</b>
<b>Unit I: Bio Process Technology and Fermentation</b> <b>1.1 Bioprocess Technology</b>		<b>Number of Lectures</b>
1.1.1 Classification of reactors based on geometry, Mode of Operations, State of mixing and energy input.		<b>08</b>
1.1.2 Types of Bioreactors- Stirred Tank, Recycle reactors, discontinuous, semi continuous and continuous.		
1.1.3 Parameters for Bio process – Bio mass, Substrates, product, O <sub>2</sub> and CO <sub>2</sub> , Temperature, agitation.		
1.1.4 Bio process monitoring with respect to O <sub>2</sub> transfer, energy transfer, rate of utilization, efficiency and computer base monitoring		
1.1.5 Downstream processing, process for product recovery, recycling of residual raw, by product recovery, waste/effluent treatment		
<b>1.2 Fermentation</b>		<b>07</b>
1.2.1 Primary and secondary of microbes, inoculums preparation, fermentation media, industrial sterilization, strain improvement, metabolic and genetic regulations during fermentations, pure and mix culture fermentations.		
1.2.2 Products from microorganisms – enzymes (Amylases, Proteases, Pectinases), Primary metabolites (Glu, vit B12), Antibiotics (Penicillin), Pigments (Carotenoids), Sweeteners, Beverages (wine, Beer)		
1.2.3 Fuels from microbes, microbial polymers and microbial steroid bio transformations.		

<p><b>Unit II: Technologies in Cell and Tissue Cultures and Marine Bio Technology.</b></p> <p><b>2.1 <u>Plant Tissue Culture (PTC)</u></b></p> <p>2.1.1 Principles, Techniques, Methodology and Application of PTC</p> <p>2.1.2 Micropropagation and Protoplast fusion</p> <p>2.1.3 Suspension Cultures for production and secondary metabolites</p> <p>2.1.4 Gene Transfer and Transgenic for crop improvement</p> <p><b>2.2 <u>Animal Tissue Culture (ATC)</u></b></p> <p>2.2.1 Principles, Techniques, Methodology and Application of ATC</p> <p>2.2.2 Transfection using eggs, cultured stem cells and nuclei in development of transgenic animals.</p> <p>2.2.3 Frontiers of contraceptive research, cryopreservation of sex gametes &amp; embryos, Ethical issues in embryo research.</p> <p><b>2.3 <u>Microbial Tissue Culture (MTC)</u></b></p> <p>2.3.1 Principles, Techniques, Methodology and Application of MTC</p> <p>2.3.2 Commercial production of industrially important microbial strains, role of ATCC and microbial cell banks.</p> <p>2.3.3 Microbes as products, Single Cell Protein (SCP) and Yeast (nutrient)</p> <p>2.3.4 Bioremediation, Oil spills, Degradation of waste water, Chemicals and heavy metals, microbial leaching (Cu, Zn, Fe, Ag, Mn, Hg, As, Sb)</p> <p><b>2.4 <u>Marine Bio Technology</u></b></p> <p>2.4.1 Principles, Techniques, Methodology and Application of Aqua Culture for Crustacean production.</p> <p>2.4.2 Medical Application of Marine resources – Anticancer and Antiviral compounds, Antimicrobial agents, Marine Toxins.</p> <p>2.4.3 Marine natural product – production of Agar and Carageenan from sea weeds and their application.</p>	<p><b>04</b></p> <p><b>04</b></p> <p><b>04</b></p> <p><b>03</b></p>
<p><b>Unit : III Techniques in Food preservation</b></p> <p><b>3.1 <u>Bio Chemistry of Food Spoilage</u></b></p> <p>3.1.1 Factors causing food spoilage during food ripening, vegetable maturation and their control.</p> <p>3.1.2 Post mortem changes in meat and their control.</p> <p><b>3.2 <u>Food Preservation</u></b></p> <p>3.2.1 General principles of food preservation</p> <p>3.2.2 Preservation by use of high and low temperatures, drying, radiations, chemical preservatives, inert gases, mechanical preservation techniques (vacuum packaging, tetra packs).</p> <p><b>3.3 <u>QC, GMP and other topics</u></b></p> <p>3.3.1 General principles of Quality Control and Good Manufacturing Practices in food industry.</p> <p>3.3.2 Determination of shelf – life of food products, transport of</p>	<p><b>05</b></p> <p><b>05</b></p> <p><b>05</b></p>

<p>perishable food items.</p> <p>3.3.3 Food Adulteration – Common food adulterants, their harmful effects and physical and chemical methods for their detection.</p> <p>3.3.4 Role of ISI Agmark and FDA in food industry.</p>	
<p><b>Unit : IV Industrial Protein Enzymes</b></p> <p><b><u>4.1 Isolation &amp; Purification</u></b></p> <p>4.1.1 Proteins &amp; Enzymes – Source identification, isolation, recovery, concentration.</p> <p>4.1.2 Partial/total purification by salting in, salting out, precipitation, ion exchange, dialysis, ultra filtration, column chromatography (Gel filtration, Affinity, HPLC)</p> <p>4.1.3 Protein characterization, functional studies, evidence of purity, mass determination mass spectroscopy.</p> <p><b><u>4.2 Production &amp; Application</u></b></p> <p>4.2.1 Therapeutic proteins – whole blood products (RBCs. Platelets, clotting factors &amp; Immunoglobulins), blood derived proteins.</p> <p>4.2.2 Vaccines &amp; Anti – toxoid Technology for measles, poliomyelitis, typhoid, Hepatitis B, AIDS, anti –tetanus.</p> <p>4.2.3 Industrial Enzymes – production &amp; applications of Proteases, Analyses, Lipases, Asparaginase, Streptokinase.</p> <p>4.2.4 Hormones – conventional &amp; engineered Insulin, Erythropoetin, Growth hormones.</p> <p>4.2.5 Interferons – production &amp; application of alpha, beta, gamma Interleukin – 2, TNF, CSF.</p> <p>4.2.6 Non – catalytic industrial proteins – casein, whey proteins, Egg proteins, wheat germ proteins.</p>	<p><b>07</b></p> <p><b>08</b></p>

Course Code	Title	Credits
PSBCH104	Research Methodology, Biostatistics & Bioinformatics	4
<b>Unit I: Research &amp; Research Design</b> <b>1.1 Research</b> 1.1.1 What is research? Meaning of research, types & significance of research, research & scientific methods. 1.1.2 Criteria for good research, problems encountered by researchers in India, selecting & defining a research problem. <b>1.2 Research Design</b> 1.2.1 Meaning, features of good research design, types of research designs. 1.2.2 Basic principles of experimental designs.		<b>Number of Lectures</b>  <b>08</b>  <b>07</b>
<b>Unit II: Presentation &amp; Processing of Data</b> <b>2.1 Presentation of Data</b> 2.1.1 Graphical presentation. 2.1.2 Tabular, chart, Diagrammatic presentation. <b>2.2 Processing of Data</b> 2.2.1 Measures of Central Tendency (Mean, Mode, Median). 2.2.2 Measures of location (Quartiles, percentiles). 2.2.3 Measures of Dispersion (Quartile deviation, Mean Deviation, Standard Deviation, Coefficient of Variation, Skewness)		<b>05</b>  <b>10</b>
<b>Unit : III Analysis of Data</b> <b>3.1 Correlation analysis</b> 3.1.1 Sample correlation analysis. 3.1.2 Multiple correlation analysis. 3.1.3 Partial correlation analysis. <b>3.2 Regression analysis</b> 3.2.1 Simple regression analysis. 3.2.2 Multiple regression analysis.		<b>07</b>  <b>08</b>
<b>Unit : IV Bioinformatics - I</b> <b>4.1 Introduction to Bioinformatics</b> 4.1.1 Definition & historical overview. 4.1.2 Major Databases in Bioinformatics. 4.1.3 Management & Analysis of biological data. 4.1.4 Molecular Biology its Central Dogma & Bioinformatics. 4.1.5 Application of Bioinformatics. <b>4.2 Information Search &amp; Data Retrieval</b> 4.2.1 Tools for Web Search 4.2.2 Data Retrieval Tools 4.2.3 Data Mining of Biological Databases.		<b>08</b>  <b>07</b>

## Detail Syllabus for Semester- I Practical

### **PSBCHP101: Calorimetry, Volumetry, Enzymology, Buffers and Microscopy**

1. Estimation of :     **Φ**
  - a. Proteins by Biuret, Bradford &Folin-Lowry methods
  - b. Amino acids by Ninhydrin method
  - c. Glucose by Anthrone&Folin-Wu methods.
  - d. Percentage Purity of Starch from Starch Hydrolystate by Willstatter's method.
2. Enzymology:             **Φ**
  - a. Amylase (Km, optimum pH, optimum temperature) from Sweet Potatoes
  - b. Urease (Km) from Jack Beans Meal/ Soya bean Seeds
  - c. Lipase (Km) from Ground Nut Seeds
  - d. Transaminase (Km) from Germinating Moong Seeds
3. Buffers and Microscopy:     **§**
  - a. pka values of Ala or Gly by Titration Curve
  - b. Microscopy: (Permanent Slides may be used)
    - i. Gram Staining
    - ii. Spores Staining
    - iii. Capsule Staining
    - iv. Acid Fast Staining

### **PSBCHP102: Biochemical/ Clinical Analysis**

1. Estimation of: ( from blood/plasma/serum/urine)
  - a. Glucose by GOD-POD Method     **§**
  - b. Tryglycerides             **§**
  - c. Cholesterol by Zak and Zaltsky Method     **§**
  - d. Calcium (Ca) by Clark and Collip Method/ Trinder Method **Φ**
  - e. Iron (Fe) by Dipyrityl Method     **Φ**
  - f. Copper (Cu) by Dithiocarbonate Method     **Φ**
  - g. Phosphorus (P) by Fiske- Subbaraow Method     **Φ**

**Φ** Experiments for Semester End Practical Examination (30Marks)

**§** Experiments for Internal Assessment in Practical (20Marks)

### **PSBCHP103: Isolation, Preparation, Extraction and Assays**

Extraction, isolation, partial purification (if necessary), calculation of percentage yield and performing a confirmatory test for the following (for serial nos. 1 to 4)

1. Proteins :
  - a. Casein from milk      **Φ**
  - b. Albumins and globulins from egg white      **§**
  - c. Proteins from germinating seeds      **§**
2. Enzymes: Extraction, Partial Purification of the following enzymes and determination of their Km values
  - a. GPT from Germinating Moong Seeds      **Φ**
  - b. Alkaline Phosphatase from Germinating Moong Seeds      **Φ**
3. Estimation of Sodium Benzoate from Jam/ Jelly      **§**

### **PSBCHP104: Research Methodology and Biostatistics**

1. Preparation of Research Proposal for Minor / Major Research Projects to be submitted to the funding agencies      **§**
2. Review of Research work being carried out at any five National/ International Research Centers or Institutes      **§**
3. One numerical problem each on      **Φ**
  - a. Measurement of Central Tendency ( Mean, Median, Mode)
  - b. Measurement of Dispersion/variability( Mean Deviation, Standard Deviation, Coefficient of variation)

**Φ** Experiments for Semester End Practical Examination (30Marks)

**§** Experiments for Internal Assessment in Practical (20Marks)

## Detail Theory Syllabus

### Semester II

Course Code	Title	Credits
PSBCH201	Advanced Bioorganic Chemistry	4
<b>Unit I:</b> <b>1.1 <u>Plant Biochemistry</u></b> 1.1.1 Chlorophylls and accessory pigments 1.1.2 Photosynthesis-Light and Dark Phases, Schemes-I, II & Z, Cyclic and Non-cyclic Photophosphorylation, C-3 & C-4 Pathways 1.1.3 Biosynthesis of Starch Sugars and Cellulose from Glucose 1.1.4 Photorespiration and photoperiodism 1.1.5 Plant growth hormones- Auxins-Gibberellines Cytokines <i>Abscisic</i> Acid and Ethylene 1.1.6 Photosynthesis in Microbes, Bacteria, Fungi, Algae and Yeast 1.1.7 Nitrogen Fixation and Sulphur Assimilation in Plants.	<b>Number of Lectures</b> <b>15</b>	
<b>Unit II:</b> <b>2.1 <u>Endocrinology</u></b> 2.1.1 Organization of Mammalian Endocrine System, Classification of Hormones 2.1.2 Biosynthesis, Storage, Secretion, Transport and Metabolic effects (including hypo and hyper conditions) of Hormones of Pituitary, Hypothalamus, Thyroid, Parathyroid, Pancreas, Adrenal Medulla, Adrenal Cortex, Gonads, Kidneys and G I Tract. 2.1.3 Mechanisms of Hormone action, Role of Secondary Messengers-cAMP, cGMP, Ca and Calmodulin	<b>15</b>	
<b>Unit : III</b> <b>3.2 <u>Biochemistry of Tissues</u></b> 3.1.1 Muscles- Structure and composition of muscle fibres, mechanism of muscle contraction and relaxation, energy source for muscular work, muscular dystrophies 3.1.2 Bones- Composition, formulation, Structure and functions, factors affecting bone metabolism, bone remodelling, osteoporosis, osteomalacia 3.1.3 Nerves- Structure of Neuron, chemistry of nerve tissue,	<b>15</b>	

3.1.4	mechanism of nerve impulse transmission, synapse and synaptic transmission, Synthesis and actions of neurotransmitters (GABA, Acetylcholine, Dopamine), Biochemistry of memory mechanisms, Blood Brain Barrier, Sensory Receptors of Taste, Vision, Odour, Hearing, Touch Connective Tissue- Biosynthesis, composition, structure and metabolism of Collagen and its Disorders-Ehler's Syndrome (Type I to VII), Osteogenesis Imperfecta (Type I to IV)	
<b>Unit : IV</b>		
<b>4.1 Bioluminescence</b>		
4.1.1	History, Source of Bioluminescence material, examples of bioluminescence organism	<b>06</b>
4.1.2	Mechanism of Bio-luminescence in specific organisms, Evolution and Bioluminescence.	
4.1.3	Use and applications of bioluminescence	
<b>4.2 Unusual Bio-molecules</b>		<b>09</b>
4.2.1	Prions, Fullerenes, Small Nuclear Riboproteins (SNURPNs), Lectins, Antifreeze proteins, Stress Proteins, Chaperons, Ionophores (Crown ethers, Cryptans)	
4.2.2	Biomimetic Chemistry- Mimicking of Ion Channels, Enzyme receptor carriers, antibodies, Vesicles and Sensors, Enzyme mimicking-Cram's Protease Model, Rebock's allosteric Model and Flavinophores for NAD	
4.2.3	Host-guest Chemistry-Cyclophanes, Calixanes, Cyclodextrins, Cyclopeptides.	

Course Code	Title	Credits
<b>PSBCH202</b>	<b>Advanced Instrumentation and Analytical Techniques</b>	<b>4</b>
<b>Unit I:</b>		<b>Number of Lectures</b>
<b>1.1 Centrifugation</b>		
1.1.1	Basic principles of sedimentation, relation between g and rpm	<b>15</b>
1.1.2	Principles, Instrumentation, Working and Applications of Preparative and Analytical Ultracentrifugation, Isopycnic Centrifugation, Rate Zonal Centrifugation	
<b>Unit II:</b>		
<b>2.1 Chromatography</b>		<b>15</b>
2.1.1	Basic Principles, Instrumentation, working and applications of partition chromatography (Paper), Absorption Chromatography (TLC, HPTLC, Column), Affinity	



Chromatography, Ion Exchange Chromatography, Permeation Chromatography, Gas-Liquid Chromatography (GLC), High Pressure Liquid Chromatography (HPLC)	
<p><b>Unit : III</b></p> <p><b>3.1 Electrophoresis</b></p> <p>3.1.1 Basic principles, factors affecting electrophoresis, support media used</p> <p>3.1.2 General principles, instrumentation, working and applications of electrophoretic techniques-zone, Disc, Capillary, 2-D, Pulsed Field Gel, Diagonal, Isoelectric Focussing, immune-electrophoresis</p> <p>3.1.3 Gel Documentation System</p> <p><b>3.2 Sequencing Techniques</b></p> <p>3.2.1 Basic Principles and Instrumentation, working and applications of-</p> <ul style="list-style-type: none"> <li>• Purification of Proteins/ Enzymes</li> <li>• Protein Sequencing Techniques</li> <li>• DNA Sequencing Techniques</li> <li>• RNA Sequencing Techniques</li> <li>• Blotting Techniques</li> </ul>	<p style="text-align: right;"><b>08</b></p> <p style="text-align: right;"><b>07</b></p>
<p><b>Unit : IV</b></p> <p><b>4.1 Special Instrumentation Methods and Analysis</b></p> <p>4.1.1 Basic Principles, Instrumentation, working and applications of experimental techniques in Flow Cytometry Electroporation, Autoclave, Inspissator</p> <p>4.1.2 Basic Principles, Instrumentation, working and application of instrumental methods of analysis in environmental methods of analysis in environmental biochemistry- Conductometry, Potentiometry, Selective Ion Meters, High Frequency Titrations, Polarography, Anode Stripping Voltammetry, Neutron Activation Analysis, Inductively Coupled Plasma Emission Spectrometry</p> <p>4.1.3 Immobilization of Enzymes and Cells</p>	<p style="text-align: right;"><b>15</b></p>

Course Code	Title	Credits
PSBCH203	Industrial Biochemistry	4
<b>Unit I: Carbohydrates of Industrial Importance</b> <b>1.1 <u>Manufacturing and refining of –</u></b> 1.1.1 Cane sugar and by products of sugar industry. 1.1.2 Production of starch, Maltodextrins, cyclodextrins, dextrose and othersweetners, inulin. 1.1.3 Manufacture of pectin & cellulose <b>1.2 <u>Manufacturing of</u></b> 1.2.1 Plant polysaccharides (Gum Arabic) 1.2.2 Microbial polysaccharides 1.2.3 Modified carbohydrates – modified starches, modified celluloses, Agarose, Sepharose.		<b>Number of Lectures</b>  <b>08</b>  <b>07</b>
<b>Unit II: Lipids of Industrial Importance</b> <b>2.1 <u>Vegetable Oils</u></b> 2.1.1 Extraction process as for palm oil, Olive oil, coconut oil, groundnut oil & Soyabean oil and Animal fats 2.1.2 Refining processes for oils and fats. <b>2.2 <u>Plant Pigments</u></b> 2.2.1 Extraction processes and applications of chlorophylls, Carotenes, Lycopenes and Turmeric. <b>2.3 <u>Essential Oils</u></b> 2.3.1 Extraction and industrial applications of essential oils (Eucalyptus, Wintergreen, Thyme, Clove, Cinnamon) <b>2.4 <u>Oleochemicals</u></b> 2.4.1 Production and application of fatty acids, glycerol, sterols, squalene, lecithin, microbial lipids, surfactants and bio surfactants. <b>2.5 <u>Tailored &amp; Modified fats</u></b> 2.5.1 Manufacture by Lipase – catalysed inter-esterification and by trans-esterification for the production of Bio-diesel (Biofuel) from Jatropha 2.5.2 Production & applications of modified lipids – low fat food items, waxes, lubricants.		<b>04</b>  <b>03</b>  <b>03</b>  <b>03</b>  <b>02</b>
<b>Unit : III Environmental Biotechnology</b> <b>3.1 <u>Air Pollution</u></b> 3.1.1 Air pollution – classification & effects of air pollutants on human health, Gases containing the oxides of carbon, sulphur and nitrogen, ozone and CFC. Measures to control air pollution and suspended particulate matters in air.		<b>04</b>

<p>3.1.2 Green house effect &amp; Global warming – sources, consequences &amp; remedial measures.</p> <p><b>3.2 <u>Water Pollution</u></b></p> <p>3.2.1 Sources and effects of water pollutants on human health, quality standards for drinking water, waste water treatment and recycling.</p> <p>3.2.2 Concept and significance of BOD, COD and dissolved oxygen.</p> <p><b>3.3 <u>Noise Pollution</u></b></p> <p>3.3.1 Sources, measurement, health hazards, prevention &amp; control of noise pollution.</p> <p><b>3.4 <u>Toxins in environment</u></b></p> <p>3.4.1 Chemical toxicology – Biochemical effects of heavy metals (Pb, As, Hg, Cd), pesticides, insecticides, herbicides, weedicides, larvicides, polyaromatic hydrocarbons, dyes, monomeric and polymeric organics.</p> <p>3.4.2 Emerging eco-friendly alternatives for chemical industry – Green chemistry and Green Technology.</p>	<p><b>04</b></p> <p><b>02</b></p> <p><b>05</b></p>
<p><b>Unit : IV Nanotechnology &amp; Other Topics</b></p> <p><b>4.1 <u>Nano biotechnology</u></b></p> <p>4.1.1 Definition and methods of preparation of nano-bioparticles.</p> <p>4.1.2 Applications in drug designing, drug delivery &amp; protein engineering.</p> <p><b>4.2 <u>Other Topics</u></b></p> <p>4.2.1 Biosensors – Construction, uses in industrial and environmental processes and medical applications.</p> <p>4.2.2 Principles, techniques and applications of – Liposome formation, natural &amp; synthetic biofilms.</p> <p>4.2.3 Clinical diagnostics – Diagnostic Kits and their applications.</p> <p>4.2.4 Concept and significance of Bio safety, Bio Hazards and Bio ethics.</p> <p>4.2.5 Concept of QC, QA GMP, GLP in labs &amp; production processes. Lab/process validation &amp; Accreditation.</p> <p>4.2.6 Maintenance &amp; Management of Lab/Experimental animals and Animal House CPCEA guidelines.</p>	<p><b>07</b></p> <p><b>08</b></p>

Course Code	Title	Credits
<b>PSBCH204</b>	<b>Research Methodology, Biostatistics &amp; Bioinformatics</b>	4
<b>Unit I: Report Writing &amp; Presentation</b> <b>1.1 Report Writing</b> 1.1.1 Significance of report writing, different steps in report writing, types of report, layout of research paper. 1.1.2 Mechanics and precautions of writing research reports for scientific journals, popular magazines, seminars/symposia/conferences/workshops, poster session. <b>1.2 Presentation</b> 1.2.1 Presentation – Oral & Written 1.2.2 Presentations in classrooms, scientific meets & public audience. 1.2.3 Defence of research thesis.		<b>Number of Lectures</b>  <b>08</b>  <b>07</b>
<b>Unit II: Sampling &amp; Estimating population parameters</b> <b>2.1 Sampling</b> 2.1.1 Representation sample, sample bias 2.1.2 Sampling Techniques – Simple random, systematic, stratified, multistage, cluster and multiphase. 2.1.3 Sampling distribution. <b>2.2 Estimating Population Parameters</b> 2.2.1 Testing of Hypothesis – Type I and Type II errors, Level of significance 2.2.2 Z – test: Paired & Unpaired 2.2.3 t-test for testing population mean (s) & proportion (s).		<b>07</b>  <b>08</b>
<b>Unit : III Chi-square &amp; other topics</b> <b>3.1 Chi – square</b> 3.1.1 Test of goodness of fit. 3.1.2 Test for independence of attributes & yate’s correction. <b>3.2 Non-parametric tests</b> 3.2.1 Introduction to non-parametric tests 3.2.2 Importance of non – parametric tests <b>3.3 Demography &amp; Vital Statistics</b> 3.3.1 Demography – collection of demographic data, collection of vital statistics at state & National levels, records of vital statistics, reports of special demographic surveys. 3.3.2 Measures of vital statistics of population such as growth and density of population ; Rates of facility, reproduction, morbidity, mortality, comprehensive indicators / indices of health.		<b>05</b>  <b>04</b>  <b>06</b>



## **PSBCHP202: Clinical Estimations**

1. Estimation of: from blood/plasma/serum/urine)
  - a. Creatinine by Jaffe's method             $\Phi$
  - b. Blood Urea Nitrogen (BUN) by Diacetyl Monoxime Method             $\Phi$
  - c. Uric Acid by Caraway method             $\Phi$
  - d. Haemoglobin by Drabkin Method         $\S$
  - e. Differential Proteins (A/G Ratio) by Reinhart Biuret Method         $\S$

## **PSBCHP203: Extraction, Isolation, Partial Purification Techniques**

Extraction, isolation, partial purification (if necessary), calculation of percentage yield and performing a confirmatory test for the following:

1. Carbohydrates:
  - a. Cellulose from Grass             $\S$
  - b. Glycogen from Liver             $\Phi$
  - c. Starch from Potato             $\Phi$
  - d. Pectin from apples/bananas/oranges             $\S$
  
2. Lipids:
  - a. Estimation of Lecithin and cholesterol from egg yolk             $\Phi$
  - b. Estimation of Essential oils from orange peels             $\Phi$
  
3. Pigments (Separation of the following pigments on TLC slides):             $\Phi$ 
  - a. Curcumin from Turmeric
  - b. Carotenes from carrots
  - c. Chlorophylls from spinach
  
4. Estimation of             $\S$ 
  - a. Total Alkalinity of Water Effluent
  - b. COD of Waste Water
  - c. Total Hardness of Well Water
  - d. Chlorides from Water Sample by Schales & Schales Method

## PSBCHP204: Biostatistics and Bio-informatics

1. One numerical problem each on  $\Phi$ 
  - a. Z-Test
  - b. T-Test
  - c. Chi-Squares Test
  - d. Simple Regression
  - e. Multiple Regression
  
2. Bioinformatics-  $\S$ 
  - a. Searches on Medline, PubMed and BioMed Central
  - b. Use of Clustal X/W for alignment of protein and nucleic acid sequences
  - c. Use of TAXON to classify Microbes and Viruses
  - d. Methods of searching databases like BLAST and FASTA
  
3. Student will be required to:
  - a.  $\S$  Access at least five scientific websites to collect relevant information with respect to the topics from the syllabus assigned to him or her by the teacher. A one [page summary per website visited (i.e. a total of five pages) should be entered in the journal as a part of practical IV. Teacher should encourage that different topics from the theory syllabus are given to student and student would access as far as possible different web sites form information collection.
  - b.  $\S$  Select any two research papers from any leading nation and international scientific journals (not older than two years) and present these papers in his or her biochemistry department as if it his/her own research work. A one page summary per research work. A one page summary per research paper presented (i.e. a total of two pages) should be entered in Journal as a part of practical IV. (Teacher may help students in selecting such research papers from the scientific journals available at their respective colleges or at other institutions/libraries). A compilation of research papers entitled "Papers in Bio-chemistry" edited by John Herriott, Gary Jacobson, Julius Marmur and William Parson published by Eddison-Wesley Publications Co. Menlo Park, California, USA may be referred to for classical original papers in biochemistry representing milestone discoveries

in bio-chemistry such as Krebs Cycles, Structure of Myoglobin and Haemoglobin, etc.

A computer terminal with an internet connection will have to be made available in the department of biochemistry for conducting Practical 204.

- Φ Experiments for Semester End Practical Examination (30Marks)
- § Experiments for Internal Assessment in Practical (20Marks)

### **Suggested Readings for Paper 101,201 and Practical 101,201.**

1. Van Holde KE – Principles of Physical Biochemistry, Prentice Hall, 1998
2. Wilson K & Walker J – Principles and Techniques of practical Biochemistry. Cambridge Low Price Edition
3. Frelfelder D- Physical Biochemistry
4. Skoog Douglas A – Principles of Instrumental Analysis Harcourt Brace publishers, London
5. Harvey David – Modern Analytical Chemistry, International edition, McGraw, Hill, Boston
6. Srivascava VK and Kishor K – Introduction to chromatography: Theory & Practice, S Chand & Co, New Delhi
7. Holme David J – Problem solving in analytical biochemistry, H & Longman Sc. And Tech, Essex
8. Brave Robert D – Introduction to Instrumental Analysis, McGraw Hill Book Co, New York
9. Ninfa Alexander J and Ballou David P – Fundamental Laboratory Approaches for Biochemistry and Biotechnology, Fitzgerald Science Press, Bethesda
10. Upadhyaya et al – Biophysical Chemistry, Himalaya Publishing Home, New Delhi
11. Rodney Boyer Experimental Biochemistry Pearson Publ. Sawheny and Singh
12. Practical Biochemistry by David Plummer
13. Methods in Enzymology – Kaplan



### **Suggested Readings for Paper 102,202 and Practical 102,202:**

1. Greenberg David M – Metabolic Pathways. Vols. 2 and 3, 3<sup>rd</sup> editions. Academic Press, New York
2. Henry Richard et al – Clinical Chemistry, Principles and Techniques, 2<sup>nd</sup> edition, Harper and Row, New York
3. Kamal SH – Clinical Biochemistry for Medical Technologies, Churchill Livingstone, London
4. Todd et al – Clinical Diagnosis and Management, 17<sup>th</sup> edition, WB Saunders, Philadelphia
5. Stokes Joan et al – Clinical Microbiology, Edward Arnold, London
6. Gill CV – Short cases in clinical biochemistry, Churchill Livingstone, Edinburgh, 1984
7. Rao Ranganathan – Text book of biochemistry 3<sup>rd</sup> edition, Prentice Hall, New Delhi
8. Rodrigues Fred K Carbohydrate chemistry with clinical correlations, New Age International, New Delhi
9. Bayens Dominiczak – Medical biochemistry, Mosby Publishers, Harcourt, 1999
10. John Bernard Henry, Clinical Diagnosis and Management by Laboratory Methods, Saunders publications, 20<sup>th</sup> edition
11. Feitz – Clinical Chemistry
12. Nelson DI, Cox MM – Lehninger Principles of Biochemistry
13. Murray Robert – Harper's biochemistry, 24<sup>th</sup> edition, Prentice Hall International UK LTD, 1990
14. Satyanarayanan – Biochemistry
15. Vasudevan Text Book of Medical Biochemistry
16. Voet & Voet – Biochemistry, 2<sup>nd</sup> edition
17. Chatterjee and Rana Shinde Medical - Biochemistry

### **Suggested Reading for Paper 103,203 and Practical 103,203:**

1. Industrial Microbiology – AH Patel, McMillan India Ltd, 1<sup>st</sup> Edition
2. Food Microbiology – Frazier & Westhoff, Tata McGraw Hill Publishers, New Delhi
3. Total synthesis of natural products, Vol I - John Apsinon
4. Chemical Process Industries – Norris Shreeve & Joseph Brink
5. Roger's Industrial Chemistry Vol I & II – Edited by CC Furnas

6. Merck Index, 10<sup>th</sup> Edition
7. Encyclopedia of chemical technology, 3<sup>rd</sup> Edition
8. Chemistry of Natural Products – Agarwal & Sharma
9. Industry chemistry of Fats and Waxes – JP Hilditch
10. Essential Oils, Vol I – Ernst Guenther
11. Natural and Synthetic colouring matter and related fields – JS Gore, Joshi
12. Encyclopedia Britannica, Vol IV & V
13. Principles of Environmental Chemistry – Kothandaram & Swaminathan, BI Publishers, Chennai
14. Environmental Chemistry – AK De, New Age International Publishers, 4<sup>th</sup> Edition
15. Molecular Biology and Biotechnology – Edited by JM Walker & EB Gingdd, Panima Educational Book Agency, New Delhi, 2<sup>nd</sup> Edition
16. GMP for pharmaceuticals, A plan for TQC – SH Wiling & JR Stoker, Marul Dekker Inc, New York, 4<sup>th</sup> Edition, 1997
17. Total Quality Assurance for the Food Industries – WA Gould & RW Gould. CTI Publications Inc, USA 1988
18. Current Good Manufacturing Practices for Food Plan Sanitation – WA Gould, CTI Publications Inc. USA 1980
19. Fundamental Concepts of Environmental Chemistry – Sodhi, Narosa Publishing House, 2002
20. Introduction to plant Biotechnology – HS Chawla, oxford & IBH Publishing Co, New Delhi, 2<sup>nd</sup> Edition.
21. Nanotechnology, A Genetic Introduction to the next big idea – Mark Ratner & Daniel Ratner, Pearson Education
22. Animal Biotechnology – Edited by AK Shrivastava, oxford & IBH publishing Co, New Delhi, 2005
23. Proteins, Biochemistry & Biotechnology – Gary Walsh, John Wiley & Sons, 2002
24. Biotechnology, An Introduction – Susan R Barnum, Vikas Publishing House, International Student Edition
25. Enzymes, Biochemistry, Biotechnology, Clinical Biochemistry – Trevor Palmer, First East-West Press Ed. 2004

### **Suggested Readings for paper 104,204 and Practical 104,204:**

1. Statistical methods for research workers – RA Fisher, 14<sup>th</sup> edition, Oliver Boyd publication
2. Statistical methods in research and production – Davelr OL & Goldsmith PL, Longman
3. Methods in biostatistics for medical students and research workers – BK Mahajan, Jaypee Brothers, New Delhi
4. Research methodology, Methods and techniques – CR Kothari Willey Eastern Ltd, Mumbai
5. Research methods – Ram Ahuja, Rawat Publications, New Delhi
6. Genetics and Biostatistics – MeyyanPillai, Saras Publication, Kanyakumari
7. Papers in Biochemistry – Jon Herriott Gary Jacobson, Julius Marmur and William parson, Addison-wesley publication Co, California
8. Experimental Biochemistry, Theory and exercises in fundamental methods – Robert Switzer and Liam Garrity, 3<sup>rd</sup> edition, WH Freeman & Co. NY
9. Computational methods in Molecular Biology – SL Slazberg (ed), Elsevier Science
10. The Molecular Biology Database Collection, An updated compilation of biological database resources in Nucleic Acid Research 2001, Academic Press
11. Using cluster for multiple sequence alignment – Higgins DG, Methods in Enzymology, 256, Academic Press
12. Modelling cellular behaviours – Endy& Brent, Nature, 409:391-395, 2001
13. Cracking the genome – Kavin Davis, Scientific American Publ.
14. Statistical methods in biological array – Davids J Finney, 3rd edition charles Griffin & co, London
15. Research Methodology – SM Israney, universal Publishing Corporation
16. Bioinformatics, Methods and protocols – edited by Stephen Messens and Stephen Krawetz, humana press, Totowa, New Jersey
17. Bioinformatics, A practical guide to analysis of genes and proteins – Andreas P Baxevanis and BF Francis Quellette, Wiley Interscience, 1998
18. Statistics for Biology – Bishop ON, 1983, Longman
19. A Textbook of Biostatistics by A Annadurai, New Age Publication
20. Bioinformatics- Methods and Applications by S C Rastogi, N. Mendiratta& P. Rastogi, PHI Learning Pvt. Ltd.

**Scheme of University Examination for M.Sc. Degree (by papers) in Theory & Practical in Biochemistry to be brought in force from 2012-2013 & progressively thereafter as Credit Based Semester And Grading System.**

**A Distribution of Credits**

Credits for Theory		Credits for Practicals	
Paper	Credits per Semester	Practical	Credit per Semester
Each	4	Each	2

Total Number of Semesters	Number of Theory Papers per Semester	Total Number of Theory Papers	Total Number of Credits
4	4	16	16 X 4 = 64 (a)
Total Number of Semesters	Number of Practicals per Semester	Total Number of Practicals	Total Number of Credits
4	4	16	16 X 2 = 32 (b)
Total Number of credits for MSc degree by papers in Biochemistry (a) + (b) = 96			

**B Distribution of Marks**

Theory Paper	Theory 100 Marks per paper					Practicals (50 Marks/Practical)		
	Semester End Theory Exam. (60)			Internal Assessment (40)		Practical	Semester End Practical Exam. (Marks)	Internal Assessment (Marks)
	No. of Units	Marks per Unit	Total Marks	Class Test (1 X 20 Marks)	Assessment (2 X 10 Marks)			
Each	04	15	60	20	20	Each	30	20

Year	Semester	Total Theory Marks (a)	Total Practical Marks (b)	Grand Total (a) + (b)
M. Sc. Part I	I	4 Papers X 100 = 400 Marks	4 Practicals X 50 = 200 Marks	600 Marks
	II	4 Papers X 100 = 400 Marks	4 Practicals X 50 = 200 Marks	600 Marks
M. Sc. Part II	I	4 Papers X 100 = 400 Marks	4 Practicals X 50 = 200 Marks	600 Marks
	II	4 Papers X 100 = 400 Marks	4 Practicals X 50 = 200 Marks	600 Marks
				2400 Marks

Use of a simple calculator shall be permitted for solving numerical and statistical problem at theory and practical examination.

1. Duration of practical examination

a. Semester-end practical examination

- i. One Day practical examination with two sessions of three hours thirty minutes each, i.e. Session I- 9am to 12:30 pm and Session II- 1:30 pm to 4:30 pm. With lunch break from 12:30pm to 1:30pm
- ii. Examination of five experiments (not more than two experiments from each practical) for 20 marks each shall be conducted over two sessions, including viva voce examination..
- iii. Only those experiments indicated by symbol  $\Phi$  in practical syllabus shall be asked in semester-end practical examination.
  - iv. Only those experiments indicated by symbol  $\S$  in practical syllabus shall be asked in the internal practical examination.

Each candidate is required to submit a certified journal for each of the semesters at the time of semester-end practical examination.