SYLLABUS BASED ON CHOICE BASED CREDIT SYSTEM

M.Sc. Applied Microbiology

SEMESTER SYSTEM
(*Effective from the session 2020-2021 Revised*)

UTKAL UNIVERSITY
VANI VIHAR, BHUBANESWAR-751004
ODISHA, INDIA

Preamble

The M.Sc. Applied Microbiology course will be effective from the academic year 2020 – 2021. It has been prepared keeping in view the unique requirements of M.Sc. Applied Microbiology students GATE, ICAR-NET, ICMR-NET and CSIR-NET syllabus. The emphasis is to provide students the latest information along with due weightage to the concepts of classical Applied Microbiology so that they are able to understand and appreciate the current interdisciplinary approaches particularly in the field of research and innovation in microbiology, life sciences and biological sciences and its role in societal development. The subject is a mixture of the traditional components with the modern aspects of biochemistry, molecular biology, genetics, industrial, medical, environmental and agricultural microbiology, immunology and biotechnology. Over the years the subject has shown enormous gain in information and applications owing to tremendous inputs from research in all its aspects. Thus the course content also lists new practical exercises so the students gets a hands on experience of the latest techniques that are currently in use. The four semesters of M.Sc. syllabus is a balanced, carefully-crafted course structure taking care of different aspects of microbiology, namely Fundamentals of microbiology, Microbial diversity, Microbial Physiology and Molecular Biology, Microbial Ecology and Genetics, Immunology, Biostatistics and Instrumentation Techniques, Microbial biotechnology, Agricultural microbiology and Plant pathology, Industrial microbiology, Environmental microbiology, Pharmaceutical and clinical microbiology. All these aspects have been given due weightage over the four semesters having special emphasis on some aspects in the last semester. Students should be encouraged to opt for one allied elective paper from other Life Sciences like Botany, Environmental science, Zoology and Biotechnology courses to increase interdisciplinary approaches of understanding and application. In recent decades, several new diseases have emerged in different geographical areas, with pathogens including Ebola virus, Zika virus, Nipah virus, and coronaviruses (CoVs). Recently, a new type of viral infection emerged which is termed as severe acute respiratory syndrome CoV-2 (SARS-CoV-2) that pose a high threat to global public health. In view of the current scenario, the course will explore new scopes in the field of microbiology and will also inspire students to pursue higher studies in Microbiology in various sectors like research, health, teaching professionals etc. The course will also enable students for becoming an entrepreneur and to get employed in several sectors. On the whole, the curriculum is a source of lot of information and is supported by rich resource materials. On behalf of M.Sc. Applied Microbiology, this new syllabus will cater the fundamental requirements for the students being employed in different sectors to serve the world as a whole.

M. Sc. APPLIED MICROBIOLOGY

Department of Botany, Utkal University, Bhubaneswar
(SEMESTER SYSTEM)

To be effective from the session 2021-2022(Revised)

Eligibility

Any student who has passed B.Sc. (Hons.) in Botany, Zoology, Life Science, Environmental science, Microbiology, Biotechnology, Pharmacy, MBBS and MVS having minimum of 50% marks in Graduation can take this course.

Admission

The candidates are to take admission after qualifying in an entrance test conducted by the department. The merit list will be prepared by taking 50% of marks in career plus 50% of marks secured by a candidate in the entrance test. The admission will be strictly as per the merit list in each category as per university norms.

Course and Regulation

1. The course is of two years duration with four semesters for theory, laboratory practical work.
2. First and second semesters have four (4) theory papers each and one (1) practical paper. Third semester has two (2) core papers, one (1) allied elective paper, one free elective paper to be opted from other department and one (1) practical paper. Fourth semester has one special paper having two (2) core elective papers, one (1) dissertation and one (1) seminar presentation. The candidate shall have to appear examination (both theory and practical / dissertation/seminar) at the end of each semester.
3. Each theory paper carries 100 marks.
4. Each practical paper carries 100 marks. In 4^{th} semester the dissertation paper carries 200 marks.
5. The semester system of examination will have internal system of evaluation as suggested by the Board of Studies approved by Teacher's council. For practical

examination evaluation will be made by one external and one internal examiner together.

6. In order to pass a semester examination a candidate must have to secure a minimum of 40% marks in practical and 33% marks in aggregate of the theory papers in each semester. If the mark secured in a theory paper is less than 25% then the said mark will not be included in the aggregate.

7. If a candidate passes all the four semester examination he / she will be declared to have passed the M.Sc. examination in Botany.

(i) In first class securing 60% or more

(ii) In second class securing 48% or more but less than 60%

(iii) In third class securing 33% marks or more but less than 48% marks in aggregate of all the semester examinations taken together.

8. Attendance in each semester shall be strictly adhered to University Rules.

9. A candidate may repeat only once in one or more papers of any semester examination within a period of one year of the said semester examination. However, if the candidate does not clear the 1^{st}& 2^{nd} semesters, his/her result will not be published even after successfully completing the 3^{rd} and 4^{th} semester. In case a candidate is unsuccessful in 3^{rd} and 4^{th} semester, he shall appear in the immediate next examination of the next batch for the same semester. A candidate failing on any semester examination will be allowed to appear once only in the examination for that semester conducted for the next batch of students and also be allowed to continue to the next semester. A candidate not appearing the 1^{st} and 2^{nd} semester examinations will be considered to have discontinued his/her study and will not be allowed to appear the remaining semesters.

10. Merit list will be prepared as per University Rules, from among the students those who have cleared all semester examinations in 1^{st} chance in one time without repeat of any paper.

11. The candidates who have failed in one semester may be allowed to appear the same in the immediate next chance, following the due provision. However, he/she will be not given another chance to appear.

12. Each unit in the papers comprises of 06 classes where each class is equal to 01 hr and 30 min.

A. Core Papers:

1. Fundamentals of microbiology
2. Microbial diversity
3. Microbial Physiology and Molecular Biology
4. Microbial Ecology and Genetics
5. Agricultural microbiology and Pathology
6. Industrial and Environmental microbiology
7. Medical microbiology
8. Antimicrobial drugs and Immunology
9. Biostatistics and Instrumentation Techniques
10. Microbial biotechnology

SWAYAM Courses

1. Biomolecules: Structure, Function in Health and Disease
2. Food Microbiology and Food Safety
3. Biostatistics and Mathematical Biology
4. Solid and hazardous Waste Management

Practical pertaining to above theory papers

B. Core Elective papers (Any one):

1. Agricultural Microbiology and Plant Pathology
2. Industrial Microbiology
3. Environmental Microbiology
4. Pharmaceutical and Clinical Microbiology

Practical pertaining to each theory core elective papers

C. Allied Elective Courses

Microbial Physiology and Genetics

D. Free Elective Courses

Microbial products and Application

Outlines of M.Sc. Applied Microbiology Syllabus

Semester-I	**Core Papers Name**	**Mark**	**Credit**
Core Papers:			
Paper-AM-101	Fundamentals of microbiology	**100**	**06**
Paper-AM-102	Microbial diversity	**100**	**06**
Paper-AM-103	Microbial Physiology and Molecular Biology (A) /Or SWAYAM Course on Biomolecules: Structure, Function in Health and Disease (B)	**100**	**06**
Paper-AM-104	Microbial Ecology and Genetics	**100**	**06**
Paper-AM-105	Practical pertaining to Theory Papers-AM-101, 102, 103& 104	**100**	**06**
	Total	**500**	**30**
Semester-II			
Paper- AM-201	Agricultural microbiology and Pathology	**100**	**06**
Paper- AM-202	Industrial and Environmental microbiology (A) /Or SWAYAM Course on Food Microbiology and Food Safety (B)	**100**	**06**
Paper- AM-203	Medical microbiology	**100**	**06**
Paper- AM-204	Antimicrobial drugs and Immunology	**100**	**06**
Paper- AM-205	Practical pertaining to Theory Papers AM-201, 202, 203& 204	**100**	**06**
	Total	**500**	**30**
Semester-III			
Paper AM-301	Biostatistics and Instrumentation Techniques (A)/Or SWAYAM Course on Biostatistics and Mathematical Biology (B)	**100**	**06**
Paper-AM-302	Microbial biotechnology	**100**	**06**
Paper-AM-303 (**Allied Elective Courses**)	Microbial Physiology and Genetics	**100**	**06**
Paper-AM-304 (**Free Elective Courses**)	Microbial products and Applications (A) /Or SWAYAM Course on Solid and hazardous Waste Management (B)	**100**	**06**
Paper-AM-305	Practical pertaining to Theory Papers –AM-301& 302	**100**	**06**
	Total	**500**	**30**
Semester-IV			
Core elective papers (Any one):**Only One Special paper +Dissertation + Seminar presentation**			
Paper-AM-401 (A)	Agricultural Microbiology and Plant Pathology-I	**100**	**06**
Paper- AM-402 (A)	Agricultural Microbiology and Plant Pathology-II	**100**	**06**
Paper-AM-401 (B)	Industrial Microbiology-I	**100**	**06**
Paper- AM-402 (B)	Industrial Microbiology-II	**100**	**06**
Paper-AM-401 (C)	Environmental Microbiology-I	**100**	**06**
Paper- AM-402 (C)	Environmental Microbiology-II	**100**	**06**
Paper-AM-401 (D)	Pharmaceutical and Clinical Microbiology-I	**100**	**06**
Paper- AM-402 (D)	Pharmaceutical and Clinical Microbiology-II	**100**	**06**
Paper- AM -403	Dissertation-cum-presentation	**200**	**12**
Paper- AM -404	Seminar presentation	**100**	**06**
	Total	**500**	**30**
	Grand Total	**2000**	**120**

SEMESTER-I

PAPER-AM-101: ***Fundamentals of Microbiology*** ***100 Marks/ 6 Credits***

Course Objectives

- To give an introduction about the microbial world- their distribution- morphology growth and about the role of microorganism in various fields of life sciences and Industry.
- Makes the student aware of the role of microbes in the daily life as well as in the various fields of science and how it can be controlled is also dealt with.

Unit-I

History of Microbial World: History, development and scope of microbiology, evolution of microbial life. Theory of Spontaneous generation. Prokaryotes, archaebacteria and eukaryotes. Classification of microbes - numerical and molecular taxonomy. Bergey's manual for identification of various microbes. Modern trends in nomenclature. Diversity of the microbial world.

Unit-II

Basic microbiological techniques: Laminar Air Flow, Autoclave, Oven, pH meter, Colony counter, Incubator-Shaker, Nephlometer, Conductivity bridge, Centrifuge, Cyclomixer. Microscopy: Bright field, Dark field, Phase contrast, Differential interference contrast, Fluorescent, Confocal scanning laser, Scanning electron, Transmission electron, Scanning tunnel microscope and Atomic force microscope.

Unit-III

Microbial nutrition: Nutritional requirements for microbes and important nutritional groups. Preparation of artificial media, different types of media used for microbial culture. Sterilization and its types. Function of different nutrients and their stress on microbes, mechanism of stress tolerance in microbes. Important groups of prokaryotes – photosynthetic bacteria, blue green algae, chemoautotrophic bacteria, spore forming bacteria, mycoplasma.

Unit-IV

Microbial growth: Methods for isolation, purification and preservation of microbes. Various cultural characteristic of microbes: colony appearance, forms, elevation, margin, colour, density, odour and consistency. Microbial staining techniques for bacteria and fungi.

Unit-V

Microbial physiology: Microbial growth curve. Growth in continuous, batch and fed-batch culture systems. Design of chemostat and turbidostat. Diauxic and synchronous growth.

Environmental factors affecting growth of microbes. Effect of physical and chemical agents on microbes. Measurement of microbial growth- direct and indirect methods.

Course outcome

At the end of this course,

- The students get trained in basic aspects of microbiology.

Reference Books

- Pelczar,Jr. Chan, B.C.s and Krej, N.R. 1993. Microbiology. MC Graw Hill-Inc. New Delhi.
- Prescott,L.M, Harley, J.P and Klein, D.A 1998. Microbiology W M C Brown Publishers. New Delhi.
- G.J. Tortora, B.R. Funke, C.L. Case Wesley Longman, NY. Microbiology- An Introduction.
- J. Heritage, E.G.V. Evans, R.A. Killington, Cambridge University Press, Introductory Microbiology
- H.D. Kumar, S. Kumar, Vikas Publishing House, Pvt. Ltd. New Delhi. Modern Concepts of Microbiology

PAPER-AM-102: ***Microbial Diversity*** ***100 Marks/ 6 Credits***

Course Objectives

- To give an introduction about the microbial diversity- their classification, morphology, structural components, reproduction and ecological importance.
- Imparts knowledge regarding microbial diversity to the students of Microbiology

Unit-I

Bacteria: Recent trends in classification and identification of bacteria. Structural and function of cell wall, flagella, fimbriae, capsule and slime layers, Filamentous protein appendages- flagella and pili, Internal structures- chromosome, plasmids, ribosomes, cytoplasmic inclusions, cytoskeleton and endospores.

Unit-II

Fungi: Role of major groups of fungi in ecosystem. Nutrition and metabolism. Nutritional adaptation. Fungal cell structure. Reproduction in fungi. Heterothallism, heterokaryosis and parasexuality. Cell structure and function of organisms under Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. Degeneration of sexuality in fungi.

Unit-III

Protozoa and algae: General characters and classification of protozoa. Reproduction in protozoa. Basic biological features of algal cell- nutrition, cell structure and reproduction. Characteristics of algal divisions- Prochlorophyceae, Euglenophyceae, Bacillariophyceae, Tribophyceae, Chrysophyceae, Cryptophyceae and Dinophyceae.

Unit-IV

Cyanobacteria: Distribution and classification of cyanobacteria. Ultra structure of cyanobacterial cells- heterocysts, cell wall, sheath, gas vacuole, pigments. Mechanism of photosynthesis in cyanobacteria. Reproduction of cyanobacteria.

Unit-V

Viruses: General characteristics of viruses. Methods used to study viruses. Viral genome and replication. Structure and classification of viruses. Transduction. Molecular regulation of lytic and lysogenic cycles. General symptoms of diseases caused by plant and animal viruses. Other infectious agents- viroids and prions.

Course outcome

At the end of this course,

- The students will get knowledge about the diversity of microorganisms which is an important aspect of Microbiology.

Reference Books

- Mehrotra, R. S. and Aneja, R. S. (1998). An Introduction to Mycology, New Age International, New Delhi.
- Alexopoulus, C. J., Mims, C. W. and Blackwel, M. (1996). Introductory Mycology, John Wiley, New York.
- Pandey. D.C. A Text Book on Algae (simple Photosynthetic Plants)
- Sharma, O.P. (1990). Text book of Algae. Tata McGraw Hill Publishing Co., Ltd., New Delhi.
- Dubey. H.C. (1990) An introduction of fungi. 2nd Edition. Vikas Publishers. ISBN PB : 9788125914334.

PAPER-AM-103 (A): ***Microbial Physiology and Molecular Biology 100 Marks/ 6 Credits***

Course Objectives

- To understand the photosynthetic efficiency of microorganisms, the basic biological activities and metabolism at DNA and protein level
- To give an introduction about the basic biochemistry related to the biological molecules, their diversity and biosynthesis.
- This also aims to develop a thorough knowledge among the students about the various biochemical reactions- metabolic pathways- responsible for the manifestation of life disease and metabolic errors.
- The course gives an in-depth insight into the molecular aspects of life - the central dogma.
- It explains molecular aspects of genes and its regulation- genome- gene expressions heredity-recombination- protein synthesis- molecular basis of diseases- mutations genetic analysis etc.

Unit-I

Microbial photosynthesis: Classification and features of photosynthetic bacteria. Basic concept of microbial photosynthesis. Biochemical reactions of photosynthesis, light reaction and light harvesting complexes. Mechanism of electron transport and ATP synthesis.

Unit-II

Bioenergetics: Glycolysis, Kreb's Cycle, Hexose monophosphate shunt, Phosphoketolase pathway, Glyoxalate pathway, Entner-Doudorff pathway, Electron transport chain. Oxidative and substrate level phosphorylation. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds).

Unit-III

Biomolecules and catalysis: Composition, structure, function and metabolism of biomolecules - carbohydrates, lipids, aminoacids and proteins, nucleic acids, vitamins and enzymes.

Unit-IV

Biomolecules and catalysis: Organization of genes and chromosomes. Conformation of nucleic acids (B, Z). Stability of double helical structure of DNA. Thermal denaturation. Quantification and supercoiled forms. DNA as genetic material. RNA- thermal stability and types. RNA as genetic material

Unit -V

Microbial Fundamental processes: DNA replication. RNA synthesis and post transcriptional modifications. Genetic code. Protein synthesis and post translational modifications, Control of gene expression at transcription and translation level in prokaryotes and in eukaryotes. Gene silencing.

Course Outcome

At the end of the course,

- The student will get an idea about the principles behind molecular biology which makes students to understand the basic molecular tools and its application in basic research and applied research in various fields of life sciences.
- The student will gain a basic working knowledge of biochemical concepts and techniques which will be necessary for future scientific endeavors.

PAPER-AM-103 (B): **SWAYAM Course on Biomolecules: Structure, Function in Health and Disease**

100 Marks/ 6 Credits

Reference Books

- Nelson, D.L., Cox M.M. (2008) Lehninger Principles of Biochemistry, 5th edn. Macmillan Publisher. 1158 pp.
- Zubay G.L. (1983) Biochemistry, 4th edition, 1999. Addison-Wesley publishers, 1268pp.
- Voet, D. and Voet, JG. (2004) Biochemistry. 3rd edition John Wiley and Sons publisher; New York. 1616 pp. ISBN: 978-0471193500.
- Stryer L. (2002). Biochemistry, 5th Revised edition, W.H.Freeman & Co publisher, 1050 pp. ISBN: 978-0716746843.
- Karp, G. Cell and Molecular Biology: Concepts and Experiments, 2000. John Wiley and Sons, New York.
- Cooper G. M. (1997). The Cell: A molecular approach. ASM Press, Washington, D. C., USA.
- Buchachnanan, B. B., Grissem, W. and Jones, R. L. J., (2000). Biochemistry and molecular biology of plants. American Society of plant physiologists, Rockville, USA
- Malacinski, G. M and Feidfelder, D (1998). Essentials of Molecular Biology, 3rd Ed. Jones and Bartel, London.
- Lewine, B. (2004) Gene VIII, Person-Prentice Hall, London.
- Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, S. Lawrence Zipursky, James Darnell. 2004. Molecular Cell Biology, Fifth Edition, W. H. Freeman and Company, New York.
- Sawhney , R Singh Introductory Practical Biochemistry Narosa Publishing House Pvt Ltd
- Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene.* 6th Ed. Pearson Education International.

PAPER-AM-104: ***Microbial Ecology and Genetics*** ***100 Marks/ 6 Credits***

Course Objectives

- To give a detailed and comprehensive knowledge on the various aspects of microbial ecology, mutation and DNA repair mechanisms and microbial genetics in detail.
- It gives the overall idea about microbes in ecosystem and how microbes interact with their environment.
- This explains the basic principles of microbial genetics and heredity and gives an overview on the classical genetics- Linkage & Crossing over.

Unit-I

Microbial ecology: Nutrient acquisition. Micro-organisms in soil, water (fresh and marine) and air. Microbial interactions- symbiosis, commenalism, parasitism, amensalism, antagonism and predation. Adaption of micro-organisms to various ecosystems. Role of microbes in biogeochemical cycling and energy flow.

Unit -II

Mutation: Mutation and types, mutagenic agents. Molecular mechanism of gene mutation- transition, transversion, frame-shift, silent, missense and non-sense mutations. Mutant types– lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Mutant selection and detection.

Unit -III

DNA repair: Molecular mechanisms of DNA repair- Direct repair. Excision repair. Mismatch repair. Recombinational repair. Repair of double stranded break. SOS repair.

Unit -IV

Microbial genetics: Homologous recombination. Site-specific recombination. Transposition.. Methods of genetic transfers- transformation, conjugation, transduction and sex-duction.

Unit -V

Gene mapping: Mapping genes by interrupted mating, fine structure analysis of genes. Gene mapping methods: linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.

Course Outcome

On completion of the course, students shall be able to,

- Identify and present relevant information from research publications dealing with issues of molecular biology and genetics.
- The course enables students to analyze hereditary data and apply fundamental coupling analyses and genetic calculations.

Reference Books

- Kosuge, T, Nester, EN (1984) Plant microbe interaction-molecular and genetic perspectives, MacMillan, New York.
- Maloy, S. R., Cronan, J. E. Jr. and Freifielder, D. (2008). Microbial Genetics, 2nd Ed. Norosa, New Delhi.
- Cooper G. M. (1997). The Cell: A molecular approach. ASM Press, Washington, D. C., USA.
- Malacinski, G. M and Feidfelder, D (1998). Essentials of Molecular Biology, 3rd Ed. Jones and Bartel, London.
- Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene.* 6th Ed. Pearson Education International.
- Klug WS & Cummings MR. 2003 *Concepts of Genetics.* Peterson Education.
- Strickberger MW.1990. *Genetics.* Collier MacMillan.
- Tamarin RH. 1999. *Principles of Genetics.* Wm. C. Brown Publs.
- Benjamin Lewin, Genes VIII, 2004, Pearson Prentice Hall, New Jersey.
- Kormondy, E. J. (1996). Concepts of Ecology, Prentice-Hall India, New Delhi.
- Odum, E. P. (1971). Fundamentals of Ecology, Saundas, Philadelphia, USA.
- Subrahmanyam, N. S. and Sambamurty, A. V. S. S. (2000). Ecology. Narosa, New Delhi.
- Klug WS & Cummings MR. 2003 *Concepts of Genetics.* Peterson Education.
- Gardner, Simmons, Snustad (2006). Principles of Genetics. 8th Ed. John Wiley & Sons, 740 pages, ISBN: 9788126510436

Paper-AM-105: *Practicals pertaining to Theory Paper-AM-101, Paper-AM-102, Paper-AM-103 and Paper-AM-104* ***100 Marks/ 6 Credits***

SEMESTER-II

Paper-AM-201: ***Agricultural Microbiology and Pathology*** ***100 Marks/ 6 Credits***

Course Objectives

- To give a detailed and comprehensive knowledge on the various aspects of plant-microbial associations, plant diseases and genetics of plant disease in detail.
- The course gives account of the microbial degradation of various organic matters.
- It also gives the overall idea about microbes in bioremediation of soil.
- Explains various beneficial plant- microbe interactions and how it can increase the efficiency of plant growth and use as bio-fertilizers for sustainable agriculture.

Unit-I

Microbial degradation: Distribution of microorganism in soil. Organic matter decomposition- humus formation, degradation of cellulose, hemicellulose, lignin, pectin and chitin. Role of microbes in the biodegradation of agricultural chemicals. Removal of heavy metals and microbial bioremediation of soil. Role of microbes in soil fertility.

Unit-II

Microbe-plant associations: Substrates released from plant, microbial processes in the rhizosphere and plant growth. Nitrogen cycle- ammonification, nitrification, denitrification, Nitogen fixation and molecular basis of biological nitrogen fixation.

Unit-III

Soil microbiology: Microorganisms of rhizosphere, phyllosphere and spermophere. Microbial interactions and their effect on plant growth. Microorganisms in transformation of phosphorus & sulphur. Mycorrhizal associations. Biofertilizers and their applications.

Unit-IV

Genetics of Plant disease: General symptoms of plant diseases. Significance and basic procedures in diagnosis of plant diseases. Aspects of pathogenesis and disease development. Plant- parasite relationship and effects of pathogens on physiology of plant. Genetics of virulence in pathogen and resistance in host plant. Defense mechanism in plants. Methods of plant disease control.

Unit-V

Plant diseases: Microbial toxins in plant disease and their types. Mechanism of biological control. General symptoms of bacterial diseases. Some important bacterial disease- Bacterial rot, bacterial blight, Leaf spot, Scab Little leaf. General symptoms of fungal diseases. Some important fungal disease- fungal rot, mildews, rust, smut, wilt, blight, blast. General symptoms of viral diseases. Some important viral disease- mosaic, leaf curl, leaf roll, bunchy top, curly top, coconut cadang- cadang.

Course Outcome

On completion of the course, students shall be able to,

- Identify several plant diseases based on external and microscopic observations.
- The course enables students to analyze and use microorganisms as bio-fertilizers for agricultural improvement.

Reference Books

- Rangaswami, G and Bagyaraj,D.J.(1996). Agricultural Microbiology 2nd edn. Prentice Hall of India New Delhi.
- Freeman, J.E.1982. Advances in microbiology. Ed. Subba Rao, (N.S) Oxford and IBH Co. New Delhi.
- Kosuge, T, Nester, EN (1984) Plant microbe interaction-molecular and genetic perspectives, MacMillan, New York.
- Kosuge, T and Nester, EN (1984) Plant microbe interaction – molecular and genetic perspectives, MacMillan, New York.
- Rangaswamy, D (1988) Disease of crop plants in India, Prentice Hall India, Ltd New Delhi.
- Asada, Y, Bbushnell, NR Ouchi. S, and vance, P (1982) Plant infection. The physiology and Biochemical basis, Springer Verlag, Berlin Nee York.

Paper-AM-202 (A): ***Industrial and Environmental Microbiology 100 Marks/ 6 Credits***

Course Objectives

- To give an introduction to the various aspects of environmental biotechnology and Food and Dairy biotechnology to the students.
- To explain the industrial aspects of microbiology for the production of various of industrial products of biological origin.
- The course explains the application of microorganisms in environment and the role of microorganisms in industrial, food and dairy technology.

Unit I

Water and waste treatment: Water bodies as habitat for microorganisms. Nutritional classification of water bodies. Factors affecting growth and activity of microbes in water. Measurement of microbiological quality of waste water. Sewage/ waste water treatment. Sludge and solid wastes treatment and disposal.

Unit-II

Microbes in degradation and mining: Biodegradable and non-biodegradable pollutants. Bioremediation- types and microbes involved. Biodegradation- hydrocarbons, pesticides, herbicides and other important compounds. Bioremediation of contaminated soil and waste lands. Genetically engineered microbes in biodegradation. Bioleaching and its significance- copper, uranium, other metals.

Unit -III

Microbes in food: Principle of food preservation- asepsis, high temperature, low temperature, cryopreservation, drying, chemical preservatives and radiations. Contamination, preservation and spoilage- cereals and cereal products, sugar and sugar products, fruits, vegetables, meat, fish and sea foods, milk and milk products. Microbiology in food sanitation.

Unit -IV

Microbes for industrial exploitation: Fermented foods- cheese, yogurt, sauerkraut, bread, sweetners, flavour enhancers. Alcohol beverages- beer, wines. Industrial production of solvents- acetone, ethanol, butanol, glycerol and vinegar.

Unit- V

Industrial biotechnology: Organic acids- citric acid, gluconic acid, acetic acid, lactic acid, L-ascorbic acid and Itaconic acid. Lipids and polysaccharides. Microbial production of antibiotics. Antibiotics in food, feed and plant disease control. Industrial production of enzymes- amylase, cellulase, protease, pectinase, lipase, phosphatase.

Course outcome

At the end of the course the students will,

- Obtain knowledge on basic principles and technologies of decontamination of persistent organic pollutants (dangerous contaminants of the environment) mainly by means of the biological approaches i.e. using bioremediation etc.
- The students will know about the principles and techniques underpinning the application of biosciences to the environment.
- Gets a detailed insight into the industrial processes carrying out in the food and dairy sector.

Paper-AM-202 (B): SWAYAM Course on Food Microbiology and Food Safety

100 Marks/ 6 Credits

Reference books

- Glazer, A.N and Nikaido. H. (1995). Microbial Biotechnology. W.H.Freeman And co. New York.
- Kumar H.D. Environmental Technology & Biosphere Management. Oxford & IBH Publishing Co. Pvt. Ltd
- R.K. Sinha and R. Sinha, 2008, Environmental Biotechnology. Aavishkar Publisher Distributors.
- Raskin, I (1999). Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. Wiley-Interscience, New York.
- Mohapatra P.K. (2006). Textbook of Environmental Biotechnology. I.K. Int. Publ., New Delhi, India. 515 pp.
- Vinod Soni and Vinay Sharma. Text Book of Environmental Biotechnology, Aavishkar publishers.
- Santra S.C. New Frontiers of Environmental Biotechnological Applications, ENVIS Centre on Environmental Biotechnology publisher.
- Nathanson J. A. Basic Environmental Technology (4th Ed.). Prentice-Hall India Pvt. Ltd.
- Demain, Arnold L. "Industrial microbiology." *Science* 214, no. 4524 (1981).
- Hans-Joachim Jordening, Josef Winter Environmental Biotechnology Concepts & Application. Willey-VCH
- Evans G.G., Furlong J. (2011). Environmental Biotechnology: Theory and Application, John Wiley & Sons, 290 pp.

- R.K. Sinha and R. Sinha, 2008, Environmental Biotechnology. Aavishkar Publisher Distributors.
- Raskin, I (1999). Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. Wiley-Interscience, New York.

Paper-AM-203: ***Medical Microbiology*** ***100 Marks/ 6 Credits***

Course Objectives

- To give an introduction to the various aspects of microorganisms involved in several human diseases to the students.
- To explain the students regarding the disease cycle, pathogenesis, diagnosis, and treatment to the students.
- The course explains the role of microorganisms in clinical aspects.

Unit-I

Microorganisms and human diseases: Koch's postulates for infectious diseases. Normal microbiota in humans. Comparative study of some infectious diseases caused by bacteria, fungi and viruses. Pathogen entering the body through the respiratory tract and its infections. Gastrointestinal tract diseases and Urinary tract infections. Food related infections.

Unit-I

Bacterial diseases: General principle of infection and communicable diseases, Disease causing agents, classification, general mode of transmission and basic treatment of the communicable and infectious diseases. Air borne diseases- Tuberculosis, Diphtheria, Meningitis, Portusis. Food borne and Water borne diseases- Cholera, Botulism, Shigellosis, Typhoid fever.

Unit-II

Contact and Fungal diseases: Soil borne diseases- tetanus and anthrax. Sexually Transmitted diseases- gonorrhea and syphilis. Contact diseases- leprosy (Tuberculoid and Lymhomatous). Fungal diseases- Mycoses, Mycotoxicoses, Dermatitis, Aspergillosis, Otomycosis.

Unit-III

Viral diseases: Air borne viral diseases- Influenza, Measles, Mumps, Rubella, Smallpox. Insect borne diseases- Yellow fever, Dengue fever. Food and water borne diseases- Polio. Direct contact diseases- Hepatitis, Rabies, Cold sores, AIDS.

Unit-IV

Protozoan diseases: Protozoan diseases caused by *Toxoplasma gondii*, *Balantidium coli*, *Trichomonas vaginalis*, *Gigardia*, *Trypanosoma*, *Entamoeba hystolytica*.

Course outcome

At the end of the course the students will,

- Obtain knowledge on basic principles and approaches of microbes invading the host system.
- Get a detailed insight into several diseases caused by different pathogens and their possible treatment and prevention strategies.

Reference Books

- Brock Biology of Microorganisms, 14th Edition. Clinical Microbiology Made Ridiculously Simple, 6th Edition.
- Microbiology: An Introduction (12th Edition) Jawetz Melnick & Adelbergs Medical Microbiology.
- Nester's Microbiology: A Human Perspective (8th Edition).
- Punt J. Kuby immunology. WH Freeman, Macmillan Learning,2019.
- Levinson, Warren, Peter Chin-Hong, Elizabeth A. Joyce, Jesse Nussbaum, and Brian Schwartz. *Review of medical microbiology and immunology*. Estados Unidos: McGraw-Hill Medical, 2008.
- Waites, Michael J., Neil L. Morgan, John S. Rockey, and Gary Higton. *Industrial microbiology: an introduction*. John Wiley & Sons, 2009.
- Ananthanarayan, R. *Ananthanarayan and Paniker's textbook of microbiology*. Orient Blackswan, 2006.
- Paniker, CK Jayaram. *Textbook of medical parasitology*. No. Ed. 6. Jaypee Brothers Medical Publishers (P) Ltd, 2007.

Paper-AM-204: ***Antimicrobial drugs and Immunology*** ***100 Marks/ 6 Credits***

Course Objectives

- To get introduced to the principles of immunology
- To introduce to the world of molecular and diagnostic techniques of immunology, immune-techniques and its application.
- This course is designed to impart the students the importance of immunology and its theoretical aspects and on the principles of immunology and immunotechnology
- The application of immunology in medicines is also dealt with.
- It also explains the various antigen-antibody reactions involved in diseases and vaccine development.

Unit-I

Antibacterial drugs: History and development of Antimicrobial drugs. General characteristics of antibacterial drugs. Mechanisms of action of antibacterial drugs that inhibit- cell wall, protein synthesis, nucleic acid and metabolic pathways.

Unit-II

Antifungal drugs: General characteristics of antifungal drugs. Mechanisms of action of antifungal drugs- plasma membrane synthesis, cell wall synthesis, cell division and nucleic acid synthesis.

Unit-III

Antiviral drugs: General characteristics of antiviral drugs. Mechanisms of action of antiviral drugs- entry inhibitors, viral uncoating, nucleic acid synthesis, integrase inhibitors and assembly and release of viral particles.

Unit-IV

Immunology: Innate immunity. Adaptive immunity. Cells of the immune system. Organs involved in adaotive immunity. Antigen. Structure and function of immunoglobulins. MHC-structure, polymorphic distribution, variation and function. Activation and differentiation of B and T cells, B and T cell receptors. Structure and functions of cytokines. Complement system. Inflammation. Antigen processing and presentation. Monoclonal antibody production and hybridoma technique.

Unit-V

Immunological disorders and immune responses: Antigen-antibody interactions. Hypersensitivity and types. Autoimmune diseases. Immunodeficiency disorders and immunotherapy. Principles of immunization. Vaccines and its role in combating diseases.

Course Outcome

At the end of the course the students will,

- Get a deep foundation in the immunological processes.
- Students will gain knowledge on how the immune system works and also on the immune system network and interactions during a disease or pathogen invasion.

Reference Books

- Nester's Microbiology: A Human Perspective (8th Edition).
- Punt J. Kuby immunology. WH Freeman, Macmillan Learning,2019.

Paper-AM-205: *Practicals pertaining to Theory Paper-AM-201, Paper-AM-202, Paper-AM-203 and Paper-AM-204* ***100 Marks/ 6 Credits***

SEMESTER-III

Paper-AM-301 (A): ***Biostatistics and Instrumentation Techniques 100 Marks/ 6 Credits***

Course Objective

- To get introduced to the fields of various instruments used in microbiology including the basic principle - application and working.
- To get idea on basic computational analysis and its applications
- The course is designed to train the students in statistics, bioinstrumentation, molecular tools and techniques essential for the understanding of life sciences and microbiology.

Unit-I

Biostatistics: Measures of central tendency and dispersion-Standard Deviation, Standard error of mean; probability distributions (Binomial, Poisson and normal). Sampling distribution. Difference between parametric and non-parametric statistics. Types of Errors, Levels of significance, Regression and Correlation. t-test, Analysis of variance, F-statistics, Chi-square test.

Unit II

Computer application: Components of Computer, Peripheral devices, Input/Output devices, Memory, Processor, Operating Systems-Windows, Linux. Application software, MS-Office, Concepts of Internet and protocols, e-correspondence. Biological database and statistical tools.

Unit-III

Spectroscopic and radioisotopic techniques: Application and Molecular analysis using UV-Visible spectrometry, Electromagnetic spectrum, Beer-Lambert's Law, Absorption, Transmission, Extinction coefficient, circular dichroism spectroscopy, NMR spectroscopy. Spectrofluoremetry. X-ray diffraction. Concepts of Raman spectroscopy. Atomic Absorption Spectrophotometry. Radioisotopes, and their molecular application.

Unit-IV

Chromatographic and electrophoretic separation techniques: Paper/column chromatography. Thin-Layer Chromatography (TLC). Gas Chromatography. Ion Exchange Chromatography. High Pressure Liquid Chromatography. Flow cytometry. Electrophoresis-types of PAGE and Agarose gel, Immuno-Electrophoresis, Isoelectric focusing.

Unit- V

Molecular Techniques: Polymerase Chain Reaction and its variations. Micro-array. Enzyme Linked Immunosorbent Assay (ELISA). Radio-immunoassay (RIA). Fluorosence in-situ Hybridization (FISH), Genomic in-situ Hybridization (GISH), Random Amplified Polymorphic DNA (RAPD), Restriction Fragment Length Polymorphism (RFLP), Amplified fragment length polymorphism (AFLP), Mass Spectroscopy, Matrix-Assisted Laser Desorption/Ionization-Time of Flight (MALDI-TOF).

Paper-AM-301 (B): SWAYAM Course on Biostatistics and Mathematical Biology

100 Marks/ 6 Credits

Course outcome

On completion of the course,

- The students will develop the capability to carry out experiments involving several instrumentation applications.
- The student will be aware with a basic knowledge of modern molecular biology and genomics
- The students will learn to approach a research problem logically and will be able to do statistical analyses in research.
- To help students to have an idea on basic mathematical problems and calculations needed in microbiological aspects.

Reference books

- Misra, B. N. and Misra, M. K. (1998). Introductory Practical Biostatistics, Naya prokash, kolkata.
- Gomez, K. A. and Gomez, A. A. ((1984). Statistical Procedures for Agricultural Research, 2nd Ed. John Weley, New York.
- K. Wilson and Walker J. Practical Biochemistry- Principles and Techniques. 5th Edn. Tata Mc. Graw Hill Publishers.
- Glick, B. R. and Pasternak (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, Washington, D. C., USA.
- Walker.J.M and Gingold. W.B. 1989. Molecular Biology and Biotechnology. 2nd edition. Royal Society of chemistry, London.
- Karp, G. Cell and Molecular Biology: Concepts and Experiments, 2000. John Wiley and Sons, New York.
- David Freifielder (1995). Molecular cell biology - 2nd Edition, Narosa publishing House.

Paper-AM-302: ***Microbial Biotechnology*** ***100 Marks/ 6 Credits***

Course Objective

- To get introduced to the industrial applications of microbes and application of microbes in recombinant DNA technology.
- The course is designed to train the students in optimization of microbial products and pathways for synthesis of secondary metabolites.
- This will also train students to design various culture systems for the growth of microorganisms for obtaining desired industrial products and use of microbes as vectors for several recombinant DNA techniques.

Unit-I

Industrial application of microbes: Characteristics and selection criteria of industrial microorganisms. Biosynthetic pathways of secondary metabolites of industrial microorganisms. Genetics of microbes in relation to industrial requirements. Pure culture methods and sources of industrial microbes.

Unit-II

Fermentation: Media (substrates) for industrial fermentation. Sterilization of culture media and gases. Isolation of microorganisms and microbial metabolic products. Principles of microbial growth and culture systems. Principles of Chemostat and Turbidostat,Bioreactors-modes of operations, Design of bioreactors. Downstream processing.

Unit-III

Optimization of microbial products: Parameters in scaling-up. Carbon substrate as energy source and terminal electron acceptor. Macro and micronutrients. pH and temperature. Absence and control of toxic materials. Bioavailability of desired microbes, Germplasm collection and maintenance.

Unit-IV

Microbes in recombinant DNA technology: Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods. DNA manipulating enzymes. Genomic and cDNA libraries. Cloning vectors. Construction of recombinant DNA molecules. Transport of recombinant DNA molecules into bacteria. Selection and identification of recombinant clones.

Unit- V

Genetic engineering of microbes for plant improvement: Ti and Ri plasmids of *Agrobacterium*. Mechanism of T-DNA transfer to plants. Binary and co-integrate vectors. Hairy root culture and their applications. Methods for direct gene transfer. Transgenic plants. Detection of transgene and its expression- Southern, northern and western blotting. Intellectual Property Rights. Patenting genetically modified microbes and plants.

Course outcome

On completion of the course,

- The students will develop the capability to carry out experiments and future research involving several recombinant DNA techniques.
- The student will be aware with a basic knowledge of parameters for design of bioreactors and optimizing conditions for desired product recovery.
- It will help students to have an idea on genetic engineering of microbes for plant improvement.

Reference books

- Pelczar,Jr. Chan, B.C.s and Krej, N.R. 1993. Microbiology. MC Graw Hill-Inc. New Delhi.
- Prescott,L.M, Harley, J.P and Klein, D.A 1998. Microbiology W M C Brown Publishers. New Delhi.
- Glazer, A.N and Nikaido. H. (1995). Microbial Biotechnology. W.H.Freeman And co. New York.
- Brown T. A. (2001). Gene Cloning and DNA Analysis. Blackwell Science, London.
- Glick, B. R. and Pasternak (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, Washington, D. C., USA.
- Keshav Trehan.1990. Biotechnology. Wiley Eastern/td. New Delhi.
- Smith, J. E. (2004) Biotechnology, 3rd edition, Cambridge University Press
- Satyanarayana U. (2005), Biotechnology. Books and Allied (P) Ltd, Kolkata. 2nd edn. 2008.
- Winnacker E - L, (2003). From Genes to Clones. Panima, New Delhi.
- Kumar.H.C. 1992. Text book on Biotechnology. East west press. New York.

***Allied Elective*:**

Paper-AM-303: ***Microbial Physiology and Genetics*** ***100 Marks/ 6 Credits***

Course Objective

- The course is designed to train the students in various aspects of microbiology such as microbial growth and nutrition, fundamental processes and genetics

Unit-I

Microbial nutrition and growth: Nutritional requirements for microbes and important nutritional groups. Preparation of artificial media, different types of media used for microbial culture. Sterilization and its types. Methods for isolation, purification and preservation of microbes. Microbial growth curve. Diauxic and synchronous growth. Environmental factors affecting growth of microbes.

Unit-II

Immunology: Cells and molecules involved in innate and adaptive immunity. Antigen. Structure and function of immunoglobulins. Activation and differentiation of B and T cells, B and T cell receptors. MHC- structure, polymorphic distribution, variation and function. Structure and functions of cytokines. Antigen processing and presentation. Complement system. Inflammation. Monoclonal antibody production and hybridoma technique.

Unit-III

Microbial Fundamental processes: Organization of genes and chromosomes. DNA as genetic material. RNA as genetic material. RNA types. DNA replication. RNA synthesis and post transcriptional modifications. Genetic code. Protein synthesis and post translational modifications, Control of gene expression at transcription and translation level in prokaryotes and in eukaryotes. Gene silencing.

Unit -IV

DNA damage and Repair: Mutation and types, mutagenic agents. Molecular mechanism of gene mutation- transition, transversion, frame-shift, silent, missense and non-sense mutations. Mutant types, selection and detection. DNA repair mechanisms.

Unit -V

Microbial genetics: Homologous and non-homologous recombination including transposition. Site-specific recombination. Methods of genetic transfers – transformation, conjugation, transduction and sex-duction. Mapping genes by interrupted mating. Gene mapping methods: linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.

Course outcome

On completion of the course,

- The students will be aware with a basic knowledge of microorganisms and their requirements for survival, growth and reproduction, central- dogma, immune system involved for upon exposure to foreign particles.

Reference Books

- Pelczar,Jr. Chan, B.C.s and Krej, N.R. 1993. Microbiology. MC Graw Hill-Inc. New Delhi.
- Prescott,L.M, Harley, J.P and Klein, D.A 1998. Microbiology W M C Brown Publishers. New Delhi.
- G.J. Tortora, B.R. Funke, C.L. Case Wesley Longman, NY. Microbiology- An Introduction.
- J. Heritage, E.G.V. Evans, R.A. Killington, Cambridge University Press, Introductory Microbiology
- H.D. Kumar, S. Kumar, Vikas Publishing House, Pvt. Ltd. New Delhi. Modern Concepts of Microbiology
- Karp, G. Cell and Molecular Biology: Concepts and Experiments, 2000. John Wiley and Sons, New York.
- Cooper G. M. (1997). The Cell: A molecular approach. ASM Press, Washington, D. C., USA.
- Buchachnanan, B. B., Grissem, W. and Jones, R. L. J., (2000). Biochemistry and molecular biology of plants. American Society of plant physiologists, Rockville, USA
- Malacinski, G. M and Feidfelder, D (1998). Essentials of Molecular Biology, 3rd Ed. Jones and Bartel, London.
- Lewine, B. (2004) Gene VIII, Person-Prentice Hall, London.
- Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, S. Lawrence Zipursky, James Darnell. 2004. Molecular Cell Biology, Fifth Edition, W. H. Freeman and Company, New York.
- Sawhney , R Singh Introductory Practical Biochemistry Narosa Publishing House Pvt Ltd
- Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene.* 6th Ed. Pearson Education International.
- Nester's Microbiology: A Human Perspective (8th Edition).
- Punt J. Kuby immunology. WH Freeman, Macmillan Learning,2019.

Free Elective:

Paper-AM-304 (A): ***Microbial Products and Applications*** ***100 Marks/ 6 Credits***

Course Objective

- The course is designed to train the students regarding use of microorganisms in bio-control of pests, microbes as food and microbes deteriorating archaeological objects.

Unit-I

Biofertilizers: Methods of production, strain Improvement, application and economics of *Rhizobium, Azospirillum,* Phosphate solubilizing Bacteria (PSB). Plant Growth Promoting Rhizobacteria (PGPR), Mycorrhizae, Cyanobacteria and *Azolla*.

Unit-II

Microbes as food: Use of microbes as source of food. Single cell protein, Fungal protein-Yeast, Algal protein-*Chlorella* and *Spirulina*. Mushroom cultivation. Agar agar extraction from *Gracillaria*. Microbial polysaccharides and polyhydroxyalkanoates.

Unit-III

Biomass and bioenergy: Management of solid waste from industries, Agriculture, mining sector and urban waste using microorganisms. Energy production from renewable sources-biogas and ethanol. Biosensors.

Unit-IV

Bio-control of pests and diseases: Microbial biopesticides. Microorganisms used in control of pest and diseases. Basic features and mode of action of *Bacillus thuringenesis*, *Trichoderma harzianum*, Nematodes and protozoa for pest control. Biological control of insects and weeds.

Unit- V

Microbes in archaeology: Microorganisms deteriorating objects, glasses, ceramics, wood and stone monuments. Methods of control of microbes for preservation of archaeological objects. Sunscreen pigments of microbes, use of sun screen pigments for protection from UV injury.

Course outcome

On completion of the course,

- The students will be aware of use microorganisms as bio-fertilizers for agricultural improvement.
- Students will get an idea regarding use of microorganisms in bio-control of pests, microbes as food and microbes deteriorating archaeological objects in will use their understanding to combat the detrimental effects.

Reference Books

- Rangaswami, G and Bagyaraj,D.J.(1996). Agricultural Microbiology 2nd edn. Prentice Hall of India New Delhi.
- Freeman, J.E.1982. Advances in microbiology. Ed. Subba Rao, (N.S) Oxford and IBH Co. New Delhi.
- Rangaswamy, D (1988) Disease of crop plants in India, Prentice Hall India, Ltd New Delhi.

Paper-AM-304 (B): SWAYAM Course on Solid and hazardous Waste Management

100 Marks/ 6 Credits

Paper-AM-305: *Practicals pertaining to Theory Paper-AM-301and Paper-AM-302*

100 Marks/ 6 Credits

SEMESTER- IV

The candidate has to choose one of the following Core elective papers.

PAPER-AM-401: AGRICULTURAL MICROBIOLOGY AND PLANT PATHOLOGY

PAPER-AM-402: INDUSTRIAL MICROBIOLOGY

PAPER-AM-403: ENVIRONMENTAL MICROBIOLOGY

PAPER-AM-404: PHARMACEUTICAL AND CLINICAL MICROBIOLOGY

AGRICULTURAL MICROBIOLOGY AND PLANT PATHOLOGY-I

PAPER-AM-401 (A): ***100 Marks/ 6 Credits***

Course Objective

- The course is designed to teach students regarding the microbial activity in rhizosphere and phyllosphere, nitrogen fixing and phosphate utilization mechanisms in microbes, diseases and resistance against diseases.

Unit I

Microbial activity in soil: General consideration on role of microbes in soil fertility. Rhizospheric microbial activity and plant nutrition uptake. Factors affecting rhizospheric, phyllospheric microbial activity and their role in nutrient uptake. Role of Plant Growth Promoting Rhizobacteria (PGPR). Role of saprophytic microbes in plant protection.

Unit-II

Nitrogen fixation and phosphate solubilization: Symbiotic nitrogen fixation-physiology and molecular mechanism, Nitrogen fixation in nodulated non-leguminous plants. *Anabaena-Azolla* system, leaf nodules, free living and associative Nitrogen fixation. Phosphate solubilization by soil microorganism, Phosphate Solubilizing Bacteria (PSB), Mycorrhizae.

Unit-III

Pathogenic plant diseases: Plant pathogens- bacteria, fungi, viruses, nematodes and mycoplasma. General symptoms and transmission of plant diseases. Some important plant diseases- rust, smuts, crown gall, wilt, tungro, citrus cancker, root knot disease.

Unit-IV

Non-pathogenic plant diseases: Diseases due to nutritional deficiency, stress, rainfall, wind, agrochemicals, heavy metals, industrial pollutants and genetic defects.

Unit- V

Disease resistance: Physiological and biochemical aspects of disease development. Chemicals involved in disease resistance and defense mechanism. Synthesis of secondary metabolites, phytoalexins. Genetics of disease resistance. Breeding for disease resistance, production of new races, induction of disease resistance through genetic engineering technique.

Course outcome

On completion of the course,

- Students will get an idea about several mechanisms for nutrition uptake by microorganisms, various pathogenic and non- pathogeneic plants diseases and their resistance in terms of physiological, biochemical and genetic aspects.

Reference Books

- Rangaswami, G and Bagyaraj,D.J.(1996). Agricultural Microbiology 2nd edn. Prentice Hall of India New Delhi.
- Kosuge, T, Nester, EN (1984) Plant microbe interaction-molecular and genetic perspectives, MacMillan, New York.
- Rao, NS Subba, ed. *Advances in agricultural microbiology*. Elsevier, 2016.
- Johansson, Jonas F., Leslie R. Paul, and Roger D. Finlay. "Microbial interactions in the mycorrhizosphere and their significance for sustainable agriculture." *FEMS microbiology ecology* 48, no. 1 (2004).
- Reddy, S. M., S. Girisham, and G. Narendra Babu. *Applied Microbiology (agriculture, environmental, food and industrial microbiology)*. Scientific Publishers, 2017.
- Yadav, Ajar Nath, Joginder Singh, Ali Asghar Rastegari, and Neelam Yadav, eds. *Plant microbiomes for sustainable agriculture*. Vol. 25. Cham: Springer, 2020.
- Verma, D.K. ed., 2019. *Microbiology for sustainable agriculture, soil health, and environmental protection*. CRC Press.
- Dhingra, Onkar D., and James Burton Sinclair. *Basic plant pathology methods*. CRC Press, Inc., 1985.
- Lucas, J.A., 2020. *Plant pathology and plant pathogens*. John Wiley & Sons.
- Dasgupta, M. K. *Principles of plant pathology*. Allied Publishers, 1988.

AGRICULTURAL MICROBIOLOGY AND PLANT PATHOLOGY-II

Paper-AM-402 (A): ***100 Marks/ 6 Credits***

Course Objective

- The course is designed to impart students about microbes use in compositing, bioenergy production.
- The course will also provide insights into use of microbes as biofertilizers and transgenic manipulations.

Unit-I

Microbes in composting: Biogeochemical cycle and microbial diversity in soil. Organic matter decomposition by soil microbes. Factors affecting microbial community in soil. Organic composting.

Unit-II

Biomass and bioenergy: Biogas production. Alcohol from agricultural waste. Production of ethanol from cellulose, pentoses. Utilization of solid waste as source of agricultural manure.

Unit-III

Biology and cultivation of mushrooms: Edible and poisonous mushrooms. Morphology and classification, nutritional value, conservation of mushrooms. Microbiology of mushroom cultivation. Cultivation of different types of mushrooms such as *Agaricus* species, *Plearotus* sp. And *Volvartella* sp. Pest and diseases of mushroom.

Unit-IV

Biofertilizers: General feature, types, merits and demerits of biofertilizers. Isolation, culture and mass production of biofertilzers - *Rhizobia*, Phosphate Solubilizing Bacteria (PSB), Mycorrhizae, *Azotobacter* and *Azospirillum*, BGA and *Azolla*.

Unit- V

Transgenic manipulation: Introduction of alien genes into crop plants through prokaryotic vector molecules. Genetic engineering in- herbicide tolerance, resistance to biotic stress (insects, viruses, fungal/bacterial pathogens, nematodes) and abiotic stress (salinity, drought, oxidative, temperature). Transgenic crops with genetic improvements.

Course outcome

On completion of the course,

- Students will get an idea about microbial uses for improving agriculture and combacting several plant diseases and will help in future research in the field of sustainable agriculture.

Reference Books

- Rangaswami, G and Bagyaraj,D.J.(1996). Agricultural Microbiology 2nd edn. Prentice Hall of India New Delhi.
- Kosuge, T, Nester, EN (1984) Plant microbe interaction-molecular and genetic perspectives, MacMillan, New York.
- Rao, NS Subba, ed. *Advances in agricultural microbiology*. Elsevier, 2016.
- Johansson, Jonas F., Leslie R. Paul, and Roger D. Finlay. "Microbial interactions in the mycorrhizosphere and their significance for sustainable agriculture." *FEMS microbiology ecology* 48, no. 1 (2004).
- Reddy, S. M., S. Girisham, and G. Narendra Babu. *Applied Microbiology (agriculture, environmental, food and industrial microbiology)*. Scientific Publishers, 2017.
- Yadav, Ajar Nath, Joginder Singh, Ali Asghar Rastegari, and Neelam Yadav, eds. *Plant microbiomes for sustainable agriculture*. Vol. 25. Cham: Springer, 2020.
- Verma, D.K. ed., 2019. *Microbiology for sustainable agriculture, soil health, and environmental protection*. CRC Press.
- Dhingra, Onkar D., and James Burton Sinclair. *Basic plant pathology methods*. CRC Press, Inc., 1985.
- Lucas, J.A., 2020. *Plant pathology and plant pathogens*. John Wiley & Sons.
- Dasgupta, M. K. *Principles of plant pathology*. Allied Publishers, 1988.

INDUSTRIAL MICROBIOLOGY-I

Paper-AM-401 (B): ***100 Marks/ 6 Credits***

Course Objective

- The course will provide knowledge regarding fermentation technologies, and use of microbes for industrial exploitations.

Unit-I

Microbial growth and metabolites: Scope and Characteristics of industrial microorganisms. Growth and basic metabolic processes. Biosynthetic pathways of microbial secondary metabolites. Genetic engineering of microbes in relation to industrial requirements.

Unit-II

Fermentation: Basic principles of fermentation technology. Culture systems- batch, fed- batch, continous. Growth and fermentation kinetics. Design of chemostat and turbidostat. Production and preservation of starter culture. Development of inocula, assay of fermentation products. Types of fermentation- surfaces, submerge and solid state fermentation.

Unit-III

Bioreactors- Designs, mode of operation and ideal reactors. Optimization conditions, aeration, agitation, foam control, process control equipments. Downstream processing- Product separation, concentration, purification and recovery.

Unit-IV

Microbes as food: Single cell protein. Fats and polysaccharides. Culture and mass cultivation of *Spirulina*, Yeast technology. Mushrooms.

Unit- V

Microbes for industrial exploitation: Fermented foods- cheese, yogurt, sauerkraut, bread, sweetners, flavour enhancers, pickles. Alcohol beverages- beer, wines. Industrial production of solvents- acetone, ethanol, butanol, glycerol, vinegar. Vitamin B-12 and Gibberellins.

Course outcome

On completion of the course,

- Students will get an overall idea regarding design of bioreactors, use of culture systems for several industrial product formations as well as downstream processing.

Reference Books

- Pelczar,Jr. Chan, B.C.s and Krej, N.R. 1993. Microbiology. MC Graw Hill-Inc. New Delhi.
- Prescott,L.M, Harley, J.P and Klein, D.A 1998. Microbiology W M C Brown Publishers. New Delhi.
- Glazer, A.N and Nikaido. H. (1995). Microbial Biotechnology. W.H.Freeman And co. New York.
- Waites, Michael J., Neil L. Morgan, John S. Rockey, and Gary Higton. *Industrial microbiology: an introduction*. John Wiley & Sons, 2009.
- Okafor, Nduka, and Benedict C. Okeke. *Modern industrial microbiology and biotechnology*. CRC Press, 2017.
- Rhodes, A. and Fletcher, D.L., 1966. Principles of industrial microbiology. *Principles of industrial microbiology.*
- Reddy, S. M., S. Girisham, and G. Narendra Babu. *Applied Microbiology (agriculture, environmental, food and industrial microbiology).* Scientific Publishers, 2017.
- Satyanarayana U. (2005), Biotechnology. Books and Allied (P) Ltd, Kolkata. 2nd edn. 2008.

INDUSTRIAL MICROBIOLOGY-II

Paper-AM-402 (B): ***100 Marks/ 6 Credits***

Course Objective

- The course impart knowledge regarding several industrially important therapeutic compounds, vaccines and other important products

Unit-I
Industrial production: Organic acids- citric acid, gluconic acid, acetic acid, lactic acid, L-ascorbic acid, Fumaric acid and Itaconic acid. Lipids and polysaccharides. Production of amino acids.

Unit-II
Microbial production of therapeutic compounds: Microbial production of antibiotics. Antibiotics in food, feed and plant disease control. Industrial production of enzymes- amylase, cellulase, protease, pectinase, lipase, phosphatase.

Unit-III
Industrial production of Hormones: Production of insulin, estrogen, progesterone, testosterone, cortosil, serotonin and steroids.

Unit-IV
Industrial production of Vaccines: Coronavirus, Cholera, Tuberculosis, Tetanus, Diphtheria, Polio, Influenza, Smallpox, Hepatitis, Typhoid, Rabies and Leprosy.

Unit- V
Biopesticides: Microbial production of insecticides, Bacteria for insect pest control. Fungi for pest control. Viruses for insect pest control, Protozoa for control of insects and pests.

Course outcome
On completion of the course,

- Students will get an idea about the process and mechanisms used for successful production of industrial compounds and microbes used for the said processes.

Reference Books

- Pelczar,Jr. Chan, B.C.s and Krej, N.R. 1993. Microbiology. MC Graw Hill-Inc. New Delhi.
- Prescott,L.M, Harley, J.P and Klein, D.A 1998. Microbiology W M C Brown Publishers. New Delhi.
- Glazer, A.N and Nikaido. H. (1995). Microbial Biotechnology. W.H.Freeman And co. New York.
- Waites, Michael J., Neil L. Morgan, John S. Rockey, and Gary Higton. *Industrial microbiology: an introduction*. John Wiley & Sons, 2009.

- Okafor, Nduka, and Benedict C. Okeke. *Modern industrial microbiology and biotechnology*. CRC Press, 2017.
- Rhodes, A. and Fletcher, D.L., 1966. Principles of industrial microbiology. *Principles of industrial microbiology*.
- Reddy, S. M., S. Girisham, and G. Narendra Babu. *Applied Microbiology (agriculture, environmental, food and industrial microbiology)*. Scientific Publishers, 2017.
- Satyanarayana U. (2005), Biotechnology. Books and Allied (P) Ltd, Kolkata. 2nd edn. 2008.

ENVIRONMENTAL MICROBIOLOGY-I

Paper-AM-401 (C): ***100 Marks/ 6 Credits***

Course Objective

- The course will provide necessary information related to microorganisms in various environments and their role in the ecosystems.

Unit-I
Microbes in ecosystem: Historical background and modern breakthrough. Specific role of microbes in ecosystem. Microbial classification based on nutrition and their interaction in nature. Factors affecting microbial community.

Unit-II
Microbial ecology: Nutrient acquisition. Microbial interactions - symbiosis, synergism, commenalism, parasitism, amensalism, antagonism and predation. Adaption of micro-organisms to various ecosystems.

Unit-III
Aeromicrobiology: Occurrence and epidemiology of aerofungi. Aeromicroflora in pharmacy. Microbes in spoilage of heritage materials- temples, library and wall paintings. Phylloplane microflora and pathogens.

Unit- IV
Aquatic microbiology: Marine and fresh water microbes. Microbiology of potable water, water purification and eutrophication. Microbes as indicator of water pollution. Waste water and sewage disposal. Biofilms, remediation of water pollutants using biofilms. Methane producing microbes in aquatic environment.

Unit- V
Microbial groups: Extremophiles- their nature and applications, deep-sea extremophilic microorganisms. Thermophilic bacteria and archaea, properties and ecology of thermophiles, thermoenzymes. Acidophiles, basophiles, halophiles, halophiles, Psychrophilic and psychrotrophic microorganisms.

Course outcome
On completion of the course,

- Students will get an idea about the various groups of microorganisms, their role in various environments and their interactions with their surroundings.

Reference Books

- Kumar H.D. Environmental Technology & Biosphere Management. Oxford & IBH Publishing Co. Pvt. Ltd

- Evans G.G., Furlong J. (2011). Environmental Biotechnology: Theory and Application, John Wiley & Sons, 290 pp.
- R.K. Sinha and R. Sinha, 2008, Environmental Biotechnology. Aavishkar Publisher Distributors.
- Raskin, I (1999). Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. Wiley-Interscience, New York.
- Mohapatra P.K. (2006). Textbook of Environmental Biotechnology. I.K. Int. Publ., New Delhi, India. 515 pp.
- Vinod Soni and Vinay Sharma. Text Book of Environmental Biotechnology, Aavishkar publishers.
- Santra S.C. New Frontiers of Environmental Biotechnological Applications, ENVIS Centre on Environmental Biotechnology publisher.
- Nathanson J. A. Basic Environmental Technology (4th Ed.). Prentice-Hall India Pvt. Ltd.
- Hans-Joachim Jordening, Josef Winter Environmental Biotechnology Concepts & Application. Willey-VCH.
- Reddy, S. M., S. Girisham, and G. Narendra Babu. *Applied Microbiology (agriculture, environmental, food and industrial microbiology).* Scientific Publishers, 2017.

ENVIRONMENTAL MICROBIOLOGY-II

Pape-AM-402 (C): ***100 Marks/ 6 Credits***

Course Objective

- The course will provide necessary information related to microorganisms in leaching and bio-mining and several biotechnological and environmental management approaches.

Unit-I

Microbes in soil environment: Biofertilizers. Microbes in soil pollution. Degradation of xenobiotics. Microbes in solid waste management. Heavy metal pollution, Reclamation and waste land development through application of microbes in agriculture and afforestation.

Unit-II

Water bodies as habitat for microorganisms: Domestic and industrial waste water-nature of pollutants, associated microflora, effects, treatment and disposal. Microbes in sewage treatment, waste water treatment, Sludge treatment and hyacinth pond. Methods to study microbiological quality of waste water.

Unit-III

Microbes in air pollution: Sources of microorganisms in air pollution. Factors influencing the population and distribution of microorganisms in air, pathogenic microorganisms in air. Green house effect, microbial indicators for air pollution. Allergy. Monitoring of air pollution. Methods to collect and analyze aerosol samples.

Unit-IV

Leaching and Biomining. Bioremediation of marine oil spills. Microbes and heavy metal tolerance, abatement of heavy metal pollution. Degradation of pesticides, methane production and biogas production.

Unit- V

Biotechnology and environment management: Stabilization of mine waste through microbes. Microbes in waste land development and forestry. Environmental laws, impact assessments, precautions and patenting the technology related to development and release of genetically engineered microbes to environment.

Course outcome

On completion of the course,

- Students will be benefitted in understanding the nature of microorganisms and their role in degrading environmental hazardous pollutants to make the environment clean and safe.

Reference Books

- Kumar H.D. Environmental Technology & Biosphere Management. Oxford & IBH Publishing Co. Pvt. Ltd
- Evans G.G., Furlong J. (2011). Environmental Biotechnology: Theory and Application, John Wiley & Sons, 290 pp.
- R.K. Sinha and R. Sinha, 2008, Environmental Biotechnology. Aavishkar Publisher Distributors.
- Raskin, I (1999). Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. Wiley-Interscience, New York.
- Mohapatra P.K. (2006). Textbook of Environmental Biotechnology. I.K. Int. Publ., New Delhi, India. 515 pp.
- Vinod Soni and Vinay Sharma. Text Book of Environmental Biotechnology, Aavishkar publishers.
- Santra S.C. New Frontiers of Environmental Biotechnological Applications, ENVIS Centre on Environmental Biotechnology publisher.
- Nathanson J. A. Basic Environmental Technology (4th Ed.). Prentice-Hall India Pvt. Ltd.
- Hans-Joachim Jordening, Josef Winter Environmental Biotechnology Concepts & Application. Willey-VCH.
- Reddy, S. M., S. Girisham, and G. Narendra Babu. *Applied Microbiology (agriculture, environmental, food and industrial microbiology)*. Scientific Publishers, 2017.

PHARMACEUTICAL AND CLINICAL MICROBIOLOGY- I

Paper-AM-401 (D): ***100 Marks/ 6 Credits***

Course Objective

- The course will impart knowledge regarding various diseases of humans, chemotherapeutic used to combat diseases, and immune system.

Unit-I

Microbes and human diseases: Host parasite relations in bacterial infections, pathogenic microbes, enteric bacteria. Oral microbiology. Skin microbiology.

Unit-II

Medical pathology: Blood chemistry- clinical significance, blood groups, blood coagulation, haemoglobin structure and functions. Urine Chemistry- physical and microbial study (Albumin test, reducing sugar test, bile test, bile pigment test, ketone body test and blood pigment test, microbial test).

Unit-III

Chemotherapeutic agents: Chemotherapy and their principles. Principles of extracellular and intracellular parasitism, bacteriostatic, bacteriocidal, fungicidal, vivicidal drugs. Limitations to effective chemotherapy, Local tissues factors, Systemic host factors and super infections and drug resistance. Aspects of antimicrobial therapy, tropical therapy, combined therapy, Chemoprophylaxis. Microbial sensitivity to antimicrobial drugs.

Unit- IV

Immunology: Classification of immunity. Natural and acquired immunity. Chemical nature of antigen, antibodies. Antigen-antibody reaction and their applications. Bacterial exotoxins and endotoxins. Significance of toxoids in active immunizations, importance of booster dose. Antibody formation. Acquired immunity and immunization. Hypersensitivity and allergy.

Unit- V

Immunotherapy: General methods of preparation, storage and standardization of bacterial and viral vaccines, Immunodiagnostic agents, antitoxic sera, vaccine, serum and monoclonal antibody production.

Course outcome

On completion of the course,

- Students will be benefitted in understanding the role of immunotherapy, chemotherapeutic agents and various other treatment mechanisms to combat various pathogenic diseases of human and to create public health awareness.

Reference Books

- Denyer, Stephen P., Norman A. Hodges, and Sean P. Gorman, eds. *Hugo and Russell's pharmaceutical microbiology*. John Wiley & Sons, 2008.
- Liu, W.J. ed., 2011. *Traditional herbal medicine research methods: identification, analysis, bioassay, and pharmaceutical and clinical studies*. John Wiley & Sons.
- Denyer, Stephen P., and Rosamund M. Baird, eds. *Guide to microbiological control in pharmaceuticals and medical devices*. CRC press, 2006.
- Hugo, William Barry, and Allan Denver Russell. *Pharmaceutical microbiology*. Blackwell science, 1998.
- Tille, Patricia. *Bailey & Scott's diagnostic microbiology-E-Book*. Elsevier Health Sciences, 2015.
- Sandle, Tim. *Pharmaceutical microbiology: essentials for quality assurance and quality control*. Woodhead Publishing, 2015.
- Ananthanarayan, R. *Ananthanarayan and Paniker's textbook of microbiology*. Orient Blackswan, 2006.
- Paniker, CK Jayaram. *Textbook of medical parasitology*. No. Ed. 6. Jaypee Brothers Medical Publishers (P) Ltd, 2007.

PHARMACEUTICAL AND CLINICAL MICROBIOLOGY- II

Paper-AM-402 (D): ***100 Marks/ 6 Credits***

Course Objective

- The course will impart knowledge regarding various diseases of humans and role of antibiotics in disease control.

Unit-I

Bacteriology: Staphylococccus. Sterptococcus. Pneumococcus. Neisseria. Corynebacterium. Bacillus. Enterobacteriaceae. Mycobacterium. Vibrio. Clostridium. Bordetella. Haemophillus.

Unit-II

Virology: General properties of virus. Bacteriophages. Poxvirus. Herpesvirus. Adenoviruses. Picornaviruses. Orthomyxoviruses. Paramyxoviruses. Rhabdoviruses. Hepatitis viruses. Oncogenic viruses. Human Immunodeficiency virus- AIDS

Unit-III

Medical Mycology: General aspects of classification, laboratory diagnosis and treatment of Superficial mycoses- *Pityriasis versicolor*, *Tinea nigra*, *Piedra*, Dermatophytoses. Subcutaneous mycoses- Mycetoma, Chromomycosis, Sporotrichosis, Rhinosporidiosis, Entomophthoromycoses. Systemic mycoses- Histoplasmosis, Blastomycosis, Coccidioidomycosis.

Unit- IV

Medical Mycology: General aspects of classification, laboratory diagnosis and treatment of Opportunistic mycoses- Asperigillosis, Penicillosis, Zygomycosis, Candidosis, Cryptococcosis. Other specific fungal infections- Otomycosis, Oculomycosis, Mycotic poisioning.

Unit- IV

Antibiotics: Study of different class of drugs, their classification, mode of action, medicinal use. Steroids. Bacterial production of B-12, Penicillin, Streptomycin and Tetramycin. Microbial assay of vitamin B-12 and antibiotics. Antibiotic sensitivity to bacteria, fungi and Actinomycetes. Applications of monoclonal antibodies. Detection of human pathogens using monoclonal and polyclonal antibodies.

Course outcome

On completion of the course,

- Students will be benefitted in understanding the role of various agents and treatment mechanisms to combat various pathogenic diseases of human and to create public health awareness.

Reference Books

- Denyer, Stephen P., Norman A. Hodges, and Sean P. Gorman, eds. *Hugo and Russell's pharmaceutical microbiology*. John Wiley & Sons, 2008.
- Liu, W.J. ed., 2011. *Traditional herbal medicine research methods: identification, analysis, bioassay, and pharmaceutical and clinical studies*. John Wiley & Sons.

- Denyer, Stephen P., and Rosamund M. Baird, eds. *Guide to microbiological control in pharmaceuticals and medical devices*. CRC press, 2006.
- Hugo, William Barry, and Allan Denver Russell. *Pharmaceutical microbiology*. Blackwell science, 1998.
- Tille, Patricia. *Bailey & Scott's diagnostic microbiology-E-Book*. Elsevier Health Sciences, 2015.
- Sandle, Tim. *Pharmaceutical microbiology: essentials for quality assurance and quality control*. Woodhead Publishing, 2015.
- Ananthanarayan, R. *Ananthanarayan and Paniker's textbook of microbiology*. Orient Blackswan, 2006.
- Paniker, CK Jayaram. *Textbook of medical parasitology*. No. Ed. 6. Jaypee Brothers Medical Publishers (P) Ltd, 2007.

PAPER-AM-403 DISSERTATION-CUM-SEMINAR 200 Marks (12 Credits)

Semester-IV (Agricultural Microbiology and Plant Pathology, Industrial Microbiology, Environmental Microbiology & Pharmaceutical and Clinical Microbiology*).*

PAPER-AM-404 SEMINAR PRESENTATION 100 Marks (6 Credits)

Semester-IV (Agricultural Microbiology and Plant Pathology, Industrial Microbiology, Environmental Microbiology & Pharmaceutical and Clinical Microbiology*).*

Annexure-I

GUIDELINES FOR DISSERTATION/THESIS PREPARATION

M.Sc. Applied Microbiology, Utkal University

Preamble: This document, herein after referred to as the Thesis Guide, lists the general and specific requirements governing thesis preparation including guidelines for structuring the contents. For style, structure and presentation of the thesis, students may refer to additional style manuals or reference guides (some of which are listed below) and to the published literature in their respective field of study.

I. MLA Style Manual and Guide to Scholarly Publishing. 3rd ed. New York: Modern Language Association, 2008.
II. Booth, W.C., Colomb, G.G. and Williams, J.M. The Craft of Research. Chicago: The University of Chicago Press, 2003.
III. Publication Manual of the American Psychological Association. 6th ed. Washington, DC: APA, 2009.

Thesis Submission: To have the thesis examined, the number of thesis copies to be submitted to the Office should correspond to (a) the number of examiners (including thesis supervisors) and (b) one seminar library copy for M.Sc. degree student.

1. Statement of Thesis Preparation

1. Thesis title: ……..
2. Degree for which the thesis is submitted: ……
3 Thesis Guide was referred to for preparing the thesis.
4. Specifications regarding thesis format have been closely followed.
5. The contents of the thesis have been organized based on the guidelines.
6. The thesis has been prepared without resorting to plagiarism.
7. All sources used have been cited appropriately.
8 The thesis has not been submitted elsewhere for a degree.

(Signature of the student)
Name: Roll No.:
Department/IDP:

2. SPECIFICATIONS FOR THESIS FORMAT

Preparation of Manuscript and Copies

The thesis needs to be prepared using a standard text processing software and must be printed in black text (color for images, if necessary) using a laser printer or letter quality printer in standard typeface (Times New Roman or Arial). 2.1.2 All copies of thesis pages must be clear, sharp and even,

with uniform size and uniformly spaced characters, lines and margins on every page of good quality white paper of 70 gsm or more. 2.1.3 Thesis should be free from typographical errors.

Size and Margins

A4 is the recommended thesis size. 2.2.2 The top, bottom and right side margins should be 25 mm, whereas the left side margin should be 35 mm for both textual and non-textual (e.g., figures, tables) pages. 2.2.3 Content should not extend beyond the bottom margin except for completing a footnote, last line of chapter/subdivision, or figure/table caption. 2.2.4 A sub-head at the bottom of the page should have at least two full lines of content below it. If the sub-head is too short to allow this, it should begin on the next page. 2.2.5 All tables and figures should conform to the same requirements as text. Color may be used for figures. If tables and figures are large, they may be reduced to the standard size (provided the reduced area is not less than 50% of the original) and /or folded just once to flush with the thesis margin (if the page size does not exceed 250x360 mm). 2.2.6 Students should also submit the thesis in soft form (PDF) for storage and archival.

Page Numbering

Beginning with the first page of the text in the thesis (chapter 1), all pages should be numbered consecutively and consistently in Arabic numerals through the appendices. 2.3.2 Page numbers prior to Chapter 1 should be in lower case Roman numerals.

Line Spacing

The general text of the manuscript should be in double spacing (3 lines per inch). Long tables, quotations, footnotes, multi-line captions and bibliographic entries (references) should be in single spacing (6 lines per inch), with text size in 11 points.

Tables, Figures and Equations

All tables (tabulated data) and figures (charts, graphs, maps, images, diagrams, etc.) should be prepared, wherever possible, on the same paper used to type the text and conform to the specifications outlined earlier. They should be inserted as close to the textual reference as possible. 2.5.2 Tables, figures and equations should be numbered sequentially either throughout the thesis or chapter-wise using Arabic numerals. They are referred to in the body of the text capitalizing the first letter of the word and number, as for instance, Table 17, Figure 24, Equation (33), or Table 5.3, Figure 3.11, Equation (4.16), etc. 2.5.3 Images, Photographs, etc. must be scanned in resolution exceeding 200dpi with 256 grayscales for the monochrome images and 24 bit per pixel for the color images.

Binding

The student should submit the copies of the thesis in fully bound form (soft cover, coiled wire binding, clamping, or filing) for M.Sc. dissertation. Once the thesis is accepted, it is the student's responsibility to get it properly bound before depositing the required number of copies with the Seminar Library of the Department concerned.

3. GUIDELINES FOR STRUCTURING CONTENTS

Sequence of Contents

The following sequence for the thesis organization should be followed:

(i) Preliminaries
- Title Page
- Thesis Abstract/Synopsis
- Guide Acknowledgement and/ or Dedication (where included)
- Table of Contents List of Figures, Tables, Illustrations, Symbols, etc (wherever applicable)

(ii) Text of Thesis
- Introduction
- Review of Literature
- Materials and Methodology
- Result
- Discussion
- Summary and conclusions

(iii) Reference Material List of References, Bibliography (where included)

(iv) Appendices where included

(v) Index where included All the headings are centered (without punctuation) 25mm down the top edge of the page.

4. Reference Format

Journals

H.E. Exner, "Physical and Chemical Nature of Cemented Carbides," International Metals Review, 1979, v. 24, pp. 149-173. G.E. Spriggs, "The Importance of Atmosphere Control in Hard Metal Production," Powder Metallurgy, 1970, v. 13, n. 26, pp. 369-393.

Conference Proceedings

H.F. Fischmeister, "Development and Present Status of the Science and Technology of Hard Materials," Science of Hard Materials, R.K. Viswanadham, D.J. Rowcliffe, and J. Gurland (eds.), Plenum Press, New York, NY, USA, 1982, pp. 1-45. W.H. Baek, M.H. Hong, S. Lee, and D.T. Chung, "A Study on the Shear Localization Behavior of Tungsten Heavy Alloy," Tungsten and Refractory Metals 2, A. Bose and R.J. Dowding (eds.), Metal Powder Industries Federation, Princeton, NJ, USA, 1995, pp. 463-471.

Books

R.M. German, Powder Injection Molding, Metal Powder Industries Federation, Princeton, NJ, USA, 1990. Thesis J.L. Johnson, "Densification, Microstructural Evolution, and Thermal Properties of Liquid Phase Sintered Composites,"

Ph.D. Thesis
The Pennsylvania State University, University Park, PA, USA, 1994. Technical Reports E.G. Zukas, P.S.Z. Rogers, and R.S. Rogers, "Experimental Evidence for Spheroid Growth Mechanisms in the Liquid Phase Sintered Tungsten Based Composites,"

Informal Report
Los Alamos Scientific laboratory, USA, 1976, pp. 1-35. Patents V. Oenning and I. S. R. Clark, U. S. Patent No. 4988386, 1991.

Journals in Non-English Language
L. Weihong and T. Xiuren, "Tungsten Matrix in Cu-W Contact Materials by Impregnation Process," Powder Metallurgy Technology, 1988, v. 6, n. 8, pp. 1-4. (in Chinese).

4. CONCLUDING REMARKS

This Thesis Guide lists only the basic requirements for preparing the thesis. Over and above the aforementioned points, a thesis should be reader-friendly in both its appearance and presentation. Several aspects of thesis preparation, particularly style of writing and presentation, have not been discussed in great detail. The student should follow appropriate ideas from standard literature of his/ her area of research, and adopt a uniform style and format throughout the thesis, such as in the structural divisions/subdivisions of the thesis, in the mode of citing references and footnotes in the text, in using dimensions, units and notations, and in preparing tables and figures, etc.