To be implemented from
Academic Year 2024-25
Board of Studies
(Microbiology)
M.Sc. Course Structure (Choice Based Credit System, Under NEP Guidelines)
Basic framework of syllabus for M.Sc. II Microbiology under NEP-2020 at Abeda Inamdar Senior College of Arts, Science and Commerce (Autonomous) Pune affiliated to Savitribai Phule Pune University, Pune

Type	Paper Code	Subject	Credits	Hours
SEMESTER III				
M1	23SMMB31MM	Microbial Bioremediation	2	30
M2	23SMMB32MM	Microbial Virus Technology	2	30
M3	23SMMB33MM	Plant Pathology	2	30
M4	23SMMB34MM	Microbiome in human health	2	30
M5	23SMMB235MM	Estuarine Microbial Ecology	2	30
P1	23SMMB36MP	Practical: Microbial Bioremediation and Microbial Virus Technology	2	60
P2	23SMMB237MP	Practical: Microbiome in human health, Plant pathology and EstuarineMicrobial Ecology	2	60
(Any one from following 23SMMB38ME)				
E1	23SMMB38AME	Antimicrobial testing guidelines/CLSI	2	30
E2	23SMMB38BME	Bio cementing and biomass utilization	2	30
(Any one from following 23SMMB39ME)				
PE	23SMMB39AME	Practical: CLSI guidelines	2	30
PE	23SMMB39BME	Practical: Bio cementing and biomass utilization	2	30
Int	23SMMB31RP	Research Project	4	60
SEMESTER IV				
M1	23SMMB41MM	Pharmaceutical Microbiology	2	30
M2	23SMMB42MM	Microbial Technology	2	30
M3	23SMMB43MM	Applications of Nano biotechnology	2	30
M4	23SMMB44MM	CRISPR Technology	2	30
P1	23SMMB45MP	Practical : Nano biotechnology and CRISPR technology	2	60
P2	23SMMB46MP	Practical: Industrial Microbiology & Applications of fungi in industry	2	60
(Any one from following 23SMMB46ME)				
E1	23SMMB47AME	Bioethics and Biosafety	2	30
E2	23SMMB47BME	Microbial Growth kinetics and product formation	2	30
(Any one from following 23SMMB47ME)				
E3	23SMMB48AME	Quality Assurance in Pharmaceutical Industry	2	30
E4	23SMMB48BME	Microbial Waste Management	2	30
Int	23SMMB41RP	Research Project	6	90

***NB:** 1.One Credit Theory Paper = 15 hrs lectures per semester and 1 Hour per week

2. Two Credit Practical Paper = 60 hrs practical per semester and 4 hours per week

M.Sc. II Semester III NEP Syllabus
M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Microbial Bioremediation**
Course Code: 23SMMB31MM	**No. of Credits: 2**
Course Type: M1	**Total Teaching Hours:30**

Course Objectives	
1.	To make students learn biodegradation of hydrocarbons, azo-dyes, heavy metals and xenobiotics.
2.	To inculcate the concepts of bioaugmentation and bio-stimulation.
3.	To make students acquainted about Biosorption using live and dead biomass.

Course Outcome	
1.	Students will learn the concept of biodegradation of hydrocarbons, azo-dyes, heavy metals and xenobiotics.
2.	They will understand the concepts of bioaugmentation and bio-stimulation.
3.	Students will get acquainted about Biosorption using live and dead biomass.

Syllabus		
Credit I	**Biodegradation:**	15 hours
	Unit I	10
	1. Role of microbes in biodegradation of: a. Hydrocarbons b. Azo dyes c. Xenobiotics **2. Genetically modified microorganisms in Biodegradation:** a. Manipulation by plasmid transfer b. Manipulation by gene alteration 3. **Factors affecting microbial degradation**	
	Unit II	5
	1. **Bioaugmentation**: its applications and limitations 2. **Biostimulation**: its applications and limitations 3. **Combination strategies**	
II	**Biosorption**	15 Hours
	Unit I	
	1. Factors Affecting Biosorption 2. Mechanisms involved in the biosorption process a. Biosorption using dead microorganisms b. Biosorption using live microorganisms	9

	The mechanism of metabolic activity for heavy metal/dye uptake by live biomass: ● Biomineralization ● Bioaccumulation ● Bioprecipitation ● Biotransformation	
	Unit II	6
	1. Biosorption of Heavy metals and dyes using biosorbents living cells Bacteria, fungi, yeast and algae 2. Biosorption of heavy metals and dyes using dead biomass 3. Comparison of biosorption by live cells and dead biomass 4. Desorption and recovery 5. Advantages and disadvantages of biosorption	

Suggested References:

1. Principles and Applications of Recombinant DNA by Bernard Glick, Edition 4
2. Nzila, A., Razzak, S. A., & Zhu, J. (2016). Bioaugmentation: An Emerging Strategy of Industrial Wastewater Treatment for Reuse and Discharge. *International journal of environmentalresearch Andpublichealth*, *13*(9), 846.
3. International Journal of Environmental Bioremediation & Biodegradation, 2015, Vol. 3, No. 1, 28-39
4. Torres, E. (2020). Biosorption: A review of the latest advances. *Processes*, *8*(12), 1584.
5. Oyewole, O. A., Zobeashia, S. S. L. T., Oladoja, E. O., Raji, R. O., Odiniya, E. E., & Musa, A. M. (2019). Biosorption of heavy metal polluted soil using bacteria and fungi isolated from soil. *SN Applied Sciences*, *1*,
6. Pham, V. H. T., Kim, J., Chang, S., & Chung, W. (2022). Bacterial Biosorbents, an Efficient Heavy Metals Green Clean-Up Strategy: Prospects, Challenges, and Opportunities. *Microorganisms*, *10*(3), 610.
7. Pham, V. H. T., Kim, J., Chang, S., & Chung, W. (2022). Bacterial biosorbents, an efficient heavy metals green clean-up strategy: Prospects, challenges, and opportunities. *Microorganisms*, *10*(3), 610.
8. Shamim, S. (2018). Biosorption of heavy metals. *Biosorption*, *2*, 21-49.

Ayele, A., Haile, S., Alemu, D., &Kamaraj, M. (2021). Comparative utilization of dead and live fungal biomass for the removal of heavy metal: a concise review. *The Scientific World Journal*, *2021*.

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**MICROBIAL VIRUS TECHNOLOGY**
Course Code: 23SMMB32MM	**No. of Credits: 2**
Course Type: M2	**Total Teaching Hours: 30**

Course Objectives	
1.	To make students acquainted with the concept of isolation and characterization of bacteriophage.
2.	To inculcate various concepts of bacteriophage growth kinetics.
3.	To teach them about Phage typing.

Course Outcome	
1.	Students will understand the concepts of isolation and characterization bacteriophages.
2.	Students will understand the various concepts of bacteriophage growth kinetics
3.	Students will learn about Phage typing.

Syllabus		
Credit I	**Isolation and characterization of bacteriophages**	15 hours
	A. Isolation and general characteristics of bacteriophages: i) Abundance of bacteriophages, mycoviruses and algal viruses in the environment. ii) Bacteriophage life cycle: Lytic, Lysogeny, chronic and abortive cycle. iii) Genetic basis of lytic and lysogenic cycles. iv) Isolation of bacteriophages from various environmental samples (water, soil, and clinical samples) **B. Bacteriophage characterization with respect to growth kinetics:** i) Concept and calculations of EoP, MOI ii) Adsorption Kinetics iii) One step growth curve	
Credit II	**Applications of bacteriophages**	15 hours
	Phage based bacterial detection **A) Bacteriophages as biocontrol agents for** i. Biofilms on medical devices ii. Pathogen control in poultry iii. Food preservation iv. Aqua systems **C) Phage therapy** i. Single phage ii. Phage cocktail	

	iii.Phage formulations iv. Phage based enzymes **D) Phage display**	

Suggested References:

1.Hao Q, Bai Y, Zhou H, Bao X, Wang H, Zhang L, Lyu M, Wang S. Isolation and Characterization of Bacteriophage VA5 against *Vibrio alginolyticus*. Microorganisms. 2023 Nov 21;11(12):2822. doi: 10.3390/microorganisms11122822. PMID: 38137966; PMCID: PMC10746027.

2.Nayak T, Kakkar A, Singh RK, Jaiswal LK, Singh AK, Temple L, Gupta A. Isolation and characterization of a novel mycobacteriophage Kashi-VT1 infecting *Mycobacterium* species. Front Cell Infect Microbiol. 2023 July 21; 13:1173894. doi: 10.3389/fcimb.2023.1173894. PMID: 37545854; PMCID: PMC10400892.

3,Isolation and Identification of a Large Green Alga Virus (*Chlorella* Virus XW01) of *Mimiviridae*and Its Virophage (*Chlorella* Virus Virophage SW01) by Using Unicellular Green AlgalCulturesYijian Sheng, Zhenqi Wu, ShengzhongXu, YongjieWang,yjwang@shou.edu.cn GeneticDiversity and Evolution April 2022 Volume 96 Issue 7 e02114-21

4.Abedon, S.T. Bacteriophage Adsorption: Likelihood of Virion Encounter with Bacteria and OtherFactors Affecting Rates. Antibiotics 2023, 12, 723.

5.Tiffany Luong, Ann-CharlottSalabarria, Dwayne R. Roach, Phage Therapy in the Resistance Era:Where Do We Stand and Where Are We Going?, Clinical Therapeutics, Volume 42, Issue 9, 2020,Pages 1659-1680, ISSN 0149-2918,

6.Cell Leading edge Review Phage Therapy :From biological mechanisms to future directionsSteffanie A. Strathdee,*Graham F. Hatfull,Vivek K. Mutalik and Robert T. Schooley Cell186,January 5 , 2023 Published by Elsevier Inc.

7.Strathdee, S. A., Hatfull, G. F., Mutalik, V. K., &Schooley, R. T. (2023). Phage therapy: from biological mechanisms to future directions. Cell, 186 (1), 17-31.

8.WeronikaJaroszewicz, Joanna Morcinek-Orłowska, Karolina Pierzynowska, Lidia Gaffke, GrzegorzWęgrzyn, Phage display and other peptide display technologies, FEMS Microbiology Reviews, Volume 46, Issue 2, March 2022, fuab052

9.Krystina L. Hess,Christopher M. JewellPhage display as a tool for vaccine and immunotherapy development Bioengineering and Translational Medicine27 August 2019

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Plant Pathology**
Course Code: 23SMMB33MM	**No. of Credits: 2**
Course Type: M 3	**Total Teaching Hours:30**

Course Objectives	
1.	The students gain knowledge on general characteristics of fungi, bacteria, virus and Mycoplasma like organisms causing plant diseases.
2.	The students acquire basic knowledge on the early development & role of different micro-organism in development of plant diseases.
3.	To generate knowledge about the Host pathogen interactions at molecular level and recent molecular technologies related to plant pathology.

Course Outcome	
1.	Students will acquire knowledge about plant pathogens, diseases and their management
2.	Students will acquire knowledge on recent plant disease management tools
3.	Acquired knowledge will help in the research of genomics, proteomics, genetic engineering and resistance breeding.

Syllabus		
Credit I	**Current and emerging trends in techniques for plant pathogen detection**	15 hours
	1. Non-invasive optical and spectral detection methods, wearable nanoelectronics 2. Cultivation-based methods 3. Immunological methods 4. Nucleic acid amplification based assays 5. Nucleic acid sequencing methods 6. Transcriptome and metabolomics 7. Modern Biosensor Technology: ·Loop-mediated isothermal amplification (LAMP) assay ·Microfluidics ·Molecular imprinted polymer-based biosensor ·Lateral flow immunoassay (LFIA) ·Digital droplet PCR (ddPCR) ·CRISPR based assays Nanosensors	

Credit II	Plant disease control	15 hours
	A. 1.Biological Control of Plant Diseases: An Evolutionary and economic consideration 2. New Trends in Integrated Plant Disease Management 3. Encapsulation of Plant Biocontrol Bacteria 4. Application of machine learning in understanding plant virus pathogenesis 5. Plant disease severity assessment using convolutional neural networks B. Global challenges facing plant pathology	

Suggested References:

1. Venbrux, M., Crauwels, S., &Rediers, H. (2023). Current and emerging trends in techniques for plant pathogen detection. *Frontiers in Plant Science*, *14*, 1120968.
2. Patel, R., Mitra, B., Vinchurkar, M., Adami, A., Patkar, R., Giacomozzi, F., &Baghini, M. S. (2022). A review of recent advances in plant-pathogen detection systems. *Heliyon*.
3. He, D.-C.; He, M.-H.; Amalin, D.M.; Liu, W.; Alvindia, D.G.; Zhan, J. Biological Control of Plant Diseases: An Evolutionary and Eco-Economic Consideration.Pathogens 2021, 10, 1311.
4. SaberiRiseh R, Skorik YA, Thakur VK, Moradi Pour M, Tamanadar E, Noghabi SS. Encapsulation of Plant Biocontrol Bacteria with Alginate as a Main Polymer Material. Int J Mol Sci. 2021 Oct 16;22(20):11165. doi: 10.3390/ijms222011165. PMID: 34681825; PMCID: PMC8538305.
5. Ghosh D, Chakraborty S, Kodamana H, Chakraborty S. Application of machine learning in understanding plant virus pathogenesis: trends and perspectives on emergence, diagnosis, host-virus interplay and management. Virol J. 2022 Mar 9;19(1):42. doi: 10.1186/s12985-022-01767-5. PMID: 35264189; PMCID: PMC8905280.
6. Jeger, M., Beresford, R., Bock, C., Brown, N., Fox, A., Newton, A., ...& Yuen, J. (2021). Global challenges facing plant pathology: multidisciplinary approaches to meet the food security and environmental challenges in the mid-twenty-first century. *CABI Agriculture and Bioscience*, *2*(1), 1-18.
7. Shi, T., Liu, Y., Zheng, X., Hu, K., Huang, H., Liu, H., & Huang, H. (2023). Recent advances in plant disease severity assessment using convolutional neural networks. *Scientific Reports*, *13*(1), 2336.
8. Castro-Moretti, F. R., Gentzel, I. N., Mackey, D., & Alonso, A. P. (2020). Metabolomics as an emerging tool for the study of plant–pathogen interactions. *Metabolites*, *10*(2), 52.

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Microbiome and Human Health**
Course Code : 23SMMB34MM	**No. of Credits: 2**
Course Type: M4	**Total Teaching Hours:30**

Course Objectives	
1.	To enrich students 'knowledge related to basic concepts of Microbiome.
2.	To inculcate the concepts of oral and gut microbiome.
3.	To make students acquainted with the concepts of microbiome and human health.

Course Outcome	
1.	Students will understand the concepts of Microbiome.
2.	Students will be able to study the diversity of gut and oral microflora.
3.	Students will understand the concept and relation in microbiome and human health.

Syllabus		
Credit I	**The Human Microbiome and Its Impacts on Health**	15 hours
	a. Role of human microbiome in health and disease. b.Interaction of the microbiota with the human body in different systems. i)Digestive system ii)Respiratorysystem iii)Urinogenital system iv)Skin v)Nervous system c. Applications and future perspective of human microbiota	
Credit II	**Interplay between oral microbiota, gut microbiota in Health and systemic diseases**	15 hours
	a.Oralmicrobiome and its effect on health and diseases. b.Gutmicrobiome and its effect on health and diseases c.Interplay between oral and gut microbiota d.Contribution of interconnection between oral and gut microbiota on health and diseases	

Suggested References:

1) Quigley, E. M. (2013). Gut bacteria in health and disease. *Gastroenterology &hepatology*, *9*(9), 560.

2) Singhvi, N., Gupta, V., Gaur, M., Sharma, V., Puri, A., Singh, Y., &Lal, R. (2020). Interplay of human gut microbiome in health and wellness. *Indian journal of microbiology*, *60*, 26-36.

3) Zheng, D., Liwinski, T., &Elinav, E. (2020). Interaction between microbiota and immunity in health and disease.*Cell research*, *30*(6), 492-506.

4) Manos, J. (2022). The human microbiome in disease and pathology.*Apmis*, *130*(12), 690-705. 5)Khor, B., Snow, M., Herrman, E., Ray, N., Mansukhani, K., Patel, K. A., & Machida, C. A. (2021). Interconnections between the oral and gut microbiomes: reversal of microbial dysbiosis and the balance between systemic health and disease. *Microorganisms*, *9*(3), 496.

6) Maciel-Fiuza, M. F., Muller, G. C., Campos, D. M. S., do Socorro Silva Costa, P., Peruzzo, J., Bonamigo, R. R., &Vianna, F. S. L. (2023). Role of gut microbiota in infectious and inflammatory diseases.*Frontiers in Microbiology*, *14*, 1098386.

7) Jandhyala, S. M., Talukdar, R., Subramanyam, C., Vuyyuru, H., Sasikala, M., & Reddy, D. N. (2015). Role of the normal gut microbiota.*World journal of gastroenterology: WJG*, *21*(29), 8787.

8) Chen, Y., Zhou, J., & Wang, L. (2021). Role and mechanism of gut microbiota in human disease .*Frontiers in cellular and infection microbiology*, *11*, 86.

9) Stevens, E. J., Bates, K. A., & King, K. C. (2021). Host microbiota can facilitate pathogen infection. *PLoS pathogens*, *17*(5), e1009514.

10) Shreiner, A. B., Kao, J. Y., & Young, V. B. (2015). The gut microbiome in health and in disease.*Current opinion in gastroenterology*, *31*(1), 69.

11) Huang, X., Huang, X., Huang, Y., Zheng, J., Lu, Y., Mai, Z. & Huang, S. (2023). The oral microbiome in autoimmune diseases: friend or foe?.*Journal of Translational Medicine*, *21*(1), 1-24. 12)Lu-jun, Z. H. O. U., Bo-yan, C. H. E. N., & Sheng-zhong, D. U. A. N. (2023). Oral Microbiome and Systemic Diseases.*Journal of Sichuan University (Medical Science Edition)*, *54*(1).

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Estuarine Microbial Ecology**
Course Code:23SMMB35MM	**No. of Credits: 2**
Course Type: M5	**Total TeachingHours:30**

Course Objectives	
1.	Identify the major freshwater and estuarine ecosystems worldwide, in America/Caribbean region, and in Grenada.
2.	Identify the physical, chemical, biological, and ecological characteristics of the different freshwater and estuarine ecosystems.
3.	Understand the interactions between the dominant physical, chemical and biological components of freshwater and estuarine ecosystems.

Course Outcome	
1.	Identify and critically analyze the major anthropogenic threats to freshwater and estuarine ecosystems and the effects on their integrity.
2.	Understand the concept of Marine and estuarine natural microbial biofilms.
3.	Identify the concept of Estuarine restoration

Syllabus		
Credit I	**Microbiota and Ecosystem**	15 hours
	1. Physical , chemical, biological, and ecological characteristics of the estuarine ecosystems. 2. The Microbial Ecology of estuarine ecosystem a. Microbial food webs b. Microbial autotrophic production c. Microbial respiration and detritus degradation d. Estuarine restoration and estuarine natural microbial biofilms e. Human impacts on estuaries	
Credit II	**Estuarine Microbiology**	15 hours
	1.New molecular techniques of estuarine microbial taxa and the microbial processes that underlie the ecosystem services provided by estuaries 2.Plant–microbe and animal–microbe interactions 3.Estuarine microbial networks and relationships 4.Dynamics of Microbial Community Structure and Ecological functions in Estuarine Intertidal sediments	

Suggested References:

1. Crump, B. C., & Bowen, J. L. (2023). The Microbial Ecology of Estuarine Ecosystems. *Annual Review of Marine Science*, *16*.
2. Anderson, S. R., & Harvey, E. L. (2022). Estuarine microbial networks and relationships vary between environmentally distinct communities. *Peer J*, *10*, e14005.
3. Yi, J., Lo, L. S. H., & Cheng, J. (2020). Dynamics of microbial community structure and ecological functions in estuarine intertidal sediments. *Frontiers in Marine Science*, *7*, 585970.
4. Wyness, A. J., Fortune, I., Blight, A. J., Browne, P., Hartley, M., Holden, M., & Paterson, D. M. (2021). Ecosystem engineers drive differing microbial community composition in intertidal estuarine sediments. *Plos one*, *16*(2), e0240952.
5. Suari, Y., Dadon-Pilosof, A., Sade, T., Amit, T., Gilboa, M., Gafny, S., ...&Yahel, G. (2019). A long term physical and biogeochemical database of a hyper-eutrophicated Mediterranean micro- estuary. *Data in brief*, *27*, 104809.
6. Kellogg, C. T., McClelland, J. W., Dunton, K. H., & Crump, B. C. (2019). Strong seasonality in arctic estuarine microbial food webs. *Frontiers in Microbiology*, *10*, 2628.
7. Yang, L. Y., Huang, X. R., Neilson, R., Li, Z. L., Yang, X. R., & Su, X. X. (2023). Characterization of microbial community, ecological functions and antibiotic resistance in estuarine plastisphere.*Science of The Total Environment*, *866*, 161322.
8. Zou, D., Liu, H., & Li, M. (2020). Community, distribution, and ecological roles of estuarine archaea. *Frontiers in Microbiology*, *11*, 2060.
9. Boey, J. S., Mortimer, R., Couturier, A., Worrallo, K., & Handley, K. M. (2022). Estuarine microbial diversity and nitrogen cycling increase along sand–mud gradients independent of salinity and distance. *Environmental Microbiology*, *24*(1), 50-65.
10. Zhang, G., Bai, J., Tebbe, C. C., Zhao, Q., Jia, J., Wang, W. & Yu, L. (2021). Salinity controls soil microbial community structure and function in coastal estuarine wetlands. *Environmental Microbiology*, *23*(2), 1020-1037.

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Microbial Bioremediation and Microbial Virus Technology**
Course Code: 23SMMB36MP	**No. of Credits: 2**
Course Type: P1	**Total Teaching Hours:60**

Course Objectives	
1.	To inculcate the concept of biodegradation using microbes.
2.	To inculcate the concept of biosorption using microbes.
3.	To make students acquainted with the concept of isolation, purification and Preservation of bacteriophages.

Course Outcome	
1.	Students will learn biodegradation using microbes
2.	Students will learn biosorption using live and dead microbial mass
3.	Students will understand the concepts of isolation, purification and preservation of bacteriophages

Syllabus		
Credit I	**Microbial Bioremediation**	15 hours
	1.Biodegradation of dyes using microorganisms 2.Biosorption of heavy metals (Cu, Zn, Ag) by live and dead microorganisms-bacteria/yeast/fungi/algae 3.Biosorption of azodye using (congo red/ bismarck brown Y, Methyl orange, Sudan black) by live and dead biomass-bacteria/yeast/fungi/algae	
Credit II	**Microbial Virus Technology**	15 hours
	Isolation, Purification and Preservation of phages: A. Isolation, Enrichment and enumeration of bacteriophages from soil/ water/ clinical sample B. Purification & preservation of the isolated phage	

Suggested References:

1. Welman-Purchase MD, Castillo J, Gomez-Arias A, Matu A, Hansen RN. First insight into the natural biodegradation of cyanide in a gold tailings environment enriched in cyanide compounds.Sci Total Environ. 2024 Jan 1;906:167174. doi: 10.1016/j.scitotenv.2023.167174. Epub 2023 Sep 22. PMID: 37741393.

2.Chang CC, Tseng CC, Han TW, Barus BS, Chuech JY, Cheng SY. Effects of Lead and Zinc Exposure on Uptake and Exudation Levels, Chlorophyll-a, and Phycobiliproteins in *Sarcodiasuiae*.Int J Environ Res Public Health. 2023 Feb 5;20(4):2821. doi: 10.3390/ijerph20042821. PMID: 36833518; PMCID: PMC9957063.

3.El-Gendy MMAA, Abdel-Moniem SM, Ammar NS, El-Bondkly AMA. Bioremoval of heavy metals from aqueous solution using dead biomass of indigenous fungi derived from fertilizer industry effluents: isotherm models evaluation and batch optimization. Biometals. 2023 Dec;36(6):1307-1329. doi: 10.1007/s10534-023-00520-x. Epub 2023 Jul 10. PMID: 37428423; PMCID: PMC10684411.

4.Ackerman H.W. (2009) Phage classification and characterization. In: Clokie MRJ, Kropinski AM (Eds) Bacteriophages: methods and protocols, Volume: Isolation, characterization and interactions, Vol. 501.
Humana Press, New York.

5.AhiwaleSangeeta (2013) Bacteriophages against enteric bacterial pathogens and their potential for bioremediation of pathogen infested water bodies PhD thesis, University of Pune, Pune, Maharashtra.

6.Ahiwale S.S. (2011) In vitro management of hospital *Pseudomonas aeruginosa*biofilm using indigenous T7-like lytic phage. Curr.Microbiology. 62:335-340

7.Balan A. and Padilla G. (1997) New thermal inducible phages isolated from tropical soils. Brazilian Journal of Genetics. 20: 4

M.Sc. Semester III NEP – Autonomy 2023 Pattern)

Course Title	**Microbiome in human health, Plant pathology & Estuarine Microbial ecology**
Course Code:23SMMB37MP	**No. of Credits: 2**
Course Type: P2	**Total Teaching Hours: 60**

Course Objectives	
1.	To make students aware of microbiome and human health.
2.	Students learn about plant pathology.
3.	Students learn the concept of estuarine microbial ecology.

Course Outcome	
1.	Students will get an understanding about the relation of microbiome and human health.
2.	Students will get knowledge of plant pathology.
3.	Students will understand the concept of estuarine microbial ecology.

Syllabus		
Credit I	**Practical related to Microbiome and Plant pathology**	30 hours
	Diversity of oral microbiome of humans with respect to: A)Eating habits. B)Age C)Gender D)Geographical location **Plant Pathology** 1. Isolation of plant pathogens from different infected plant samples 2. Screening and isolation of biocontrol agents against plant pathogens	
Credit II	**Estuarine microbial ecology**	30 hours
	Estuarine Microbial Ecology 1. Isolation and identification of microbes from Estuaries. 2. Qualitative and quantitative assays of biofilms formed by estuarine microbes. 3. Hydrolytic enzyme profiling of the estuarine microbes.	

Suggested References:

1. Current Methods for Studying the Human Microbiome
2. Ambeng, H Zubair, NP Oka and A Tonggiroh Isolation and characterization of

bacteria from mangrove sediment at coastal area in Pangkep South Sulawesi J. Phys.: Conf. Ser.1341 022016

3. Hossain TJ, Chowdhury SI, Mozumder HA, Chowdhury MNA, Ali F, Rahman N, Dey S. Hydrolytic Exoenzymes Produced by Bacteria Isolated and Identified From the Gastrointestinal Tract of Bombay Duck. Front Microbiol. 2020 Aug 26;11:2097. doi: 10.3389/fmicb.2020.02097. PMID: 32983064; PMCID: PMC7479992.

4. Bacteria Isolated and Identified From the Gastrointestinal Tract of Bombay Duck. Front. Microbiol. 11:2097.doi: 3389/fmicb.2020.02097

5. Al-Mijalli SH. Isolation and characterization of plant and human pathogenic bacteria from green pepper (Capsicum annum L.) in Riyadh, Saudi Arabia. 3 Biotech. 2014 Aug;4(4):337-
344. doi: 10.1007/s13205-013-0136-2. Epub 2013 Aug 14. PMID: 28324470; PMCID: PMC4145628.

6. Venbrux M, Crauwels S and Rediers H (2023) Current and emerging trends in techniques for plant pathogen detection.Front. Plant Sci.14:1120968.doi: 10.3389/fpls.2023.1120968

7. Li X, Zhao H, Chen X. Screening of Marine Bioactive Antimicrobial Compounds for Plant Pathogens. Mar Drugs. 2021 Jan 28;19(2):69. doi: 10.3390/md19020069. PMID: 33525648; PMCID: PMC7912171.

8. Kurokawa, M., Nakano, M., Kitahata, N. *et al.* An efficient direct screening system for microorganisms that activate plant immune responses based on plant–microbe interactions using cultured plant cells. *Sci Rep* 11, 7396 (2021). https://doi.org/10.1038/s41598-021-86560- 0

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Antimicrobial testing guidelines / CLSI**
Course Code:23SMMB38AME	**No. of Credits: 2**
Course Type: E1	**Total Teaching Hours:30**

Course Objectives	
1.	To guide students about antimicrobial testing.
2.	To teach the role and responsibilities of CLSI.
3.	To make the students aware of guidelines for antimicrobial testing.

Course Outcome	
1.	Students will learn about the antimicrobial testing.
2.	Students will learn the guidelines for antimicrobial testing.
3.	Students will know about the regulatory authorities for antimicrobial testing.

Syllabus		
Credit I	**CLSI Guidelines 2023**	15 hours
	A) CLSI Standards: Guidelines for Health Care Excellence. B) Purpose of CLSI. C) Roles and responsibilities of CLSI. D) CLSI Mission & Vision: Excellence in Laboratory Medicine. E) Role of CLSI in Pharmaceutical Industry.	
Credit II	**Antimicrobial Susceptibility testing**	15 hours
	A)Selection of antimicrobials for testing and Reporting. B) Selection of Media-Liquid and Solid. C) Factors affecting susceptibility testing. D)Diffusion methods- Agar dilution technique Broth dilution Microtitre dilution Gradient plate technique E- test Kirby- Bauer test Stokes method E)Methodologies for antimicrobial susceptibility testing. MIC , MBC determination for a) Anti-mycobacterial agents b) Antifungal agents c) Antiprotozoal agents d) Antiviral agents	

Suggested References:

1) Bayot, M. L., & Bragg, B. N. (2019). Antimicrobial susceptibility testing.
2) Brook, I., Wexler, H. M., & Goldstein, E. J. (2013). Antianaerobic antimicrobials: spectrum and susceptibility testing. Clinical Microbiology Reviews, 26(3), 526-546.
3) Kassim, A., Omuse, G., Premji, Z., &Revathi, G. (2016). Comparison of Clinical Laboratory Standards Institute and European Committee on Antimicrobial Susceptibility Testing guidelines for the interpretation of antibiotic susceptibility at a University teaching hospital in Nairobi, Kenya: a cross-sectional study. Annals of clinical microbiology and antimicrobials, 15, 1-7.
4) Mwanika, E. W. (2019). Antimicrobial Susceptibility Patterns of Bacterial Isolates in Patients at Moi County Referral Hospital, Voi (Doctoral dissertation, University of Nairobi).
5) de Sousa, E. S. O., Cortez, A. C. A., de Souza CarvalhoMelhem, M., Frickmann, H., & de Souza, J. V. B. (2020). Factors influencing susceptibility testing of antifungal drugs: a critical review of document M27-A4 from the Clinical and Laboratory Standards Institute (CLSI). Brazilian Journal of Microbiology, 51, 1791-1800.
6) Salam, M. A., Al-Amin, M. Y., Pawar, J. S., Akhter, N., & Lucy, I. B. (2023). Conventional methods and future trends in antimicrobial susceptibility testing. *Saudi journal of biological sciences*, 103582.
7) Matuschek, E., Copsey-Mawer, S., Petersson, S., Åhman, J., Morris, T. E., &Kahlmeter, G. (2023). The European committee on antimicrobial susceptibility testing disc diffusion susceptibility testing method for frequently isolated anaerobic bacteria. *Clinical Microbiology and Infection*, *29*(6), 795-e1.
8) Fajt, V. R., & Lubbers, B. V. (2023). Application and Interpretation of Antimicrobial Susceptibility Testing. *Veterinary Clinics: Food Animal Practice*, *39*(1), 115-128.
9) Armengol, E. S., Harmanci, M., &Laffleur, F. (2021). Current strategies to determine antifungal and antimicrobial activity of natural compounds. *Microbiological Research*, *252*, 126867.
10) Yin, D., Guo, Y., Li, M., Wu, W., Tang, J., Liu, Y., ...& Hu, F. (2021). Performance of VITEK 2, E-test, Kirby–Bauer disk diffusion, and modified Kirby–Bauer disk diffusion compared to reference broth microdilution for testing tigecycline susceptibility of carbapenem- resistant K. pneumoniae and *A. baumannii* in a multicenter study in China. *European Journal of Clinical Microbiology & Infectious Diseases*, *40*, 1149-1154.
11) Chou, S. (2020). Advances in the genotypic diagnosis of cytomegalovirus antiviral drug resistance. *Antiviral research*, *176*, 104711.
12) Pierce, V. M., &Mathers, A. J. (2022). Setting antimicrobial susceptibility testing breakpoints: a primer for pediatric infectious diseases specialists on the Clinical and Laboratory Standards Institute approach. *Journal of the Pediatric Infectious Diseases Society*, *11*(2), 73-80.
13) Veeraraghavan, B., Bakthavatchalam, Y. D., Manesh, A., Lal, B., Swaminathan, S., Ansari, A., ...&Taklikar, S. (2023). India-discovered levonadifloxacin&alalevonadifloxacin: A review on susceptibility testing methods, CLSI quality control and breakpoints along with a brief account of their emerging therapeutic profile as a novel standard-of-care. *Indian Journal of Medical Microbiology*, *41*, 71-80.
14) McCreary, E. K., Heil, E. L., &Tamma, P. D. (2021). New perspectives on antimicrobial agents: cefiderocol. *Antimicrobial agents and chemotherapy*, *65*(8), 10-1128.

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Bio cementing and Biomass utilization**

Course Code:23SMMB38BME	**No. of Credits: 2**
Course Type: E2	**Total Teaching Hours:30**

Course Objectives	
1.	To enrich students' knowledge related to basic concepts of Bio-cementing and Biomass utilization.
2.	To inculcate the concepts of bio-cementing and biomass utilization.
3.	To make students acquainted with the concepts of Bio-cementing and Biomass utilization.

Course Outcome	
1.	Students will understand the concepts of Bio-cementing and Biomass utilization.
2.	Students will be able to study the applications of Bio-cementing**.**
3.	Students will understand the concept challenges of Bio-cementing and Biomass utilization.

Syllabus		
Credit I	**Bio-cementing**	15 hours
	Concept of Bio-cementing 1. Role of Microorganisms in Bio-cementing 2. Different microbial enzymes and their role in Bio-cementing 3. Soil Bio-cementation treatment strategies a) Submerged treatment method b) Surface percolation treatment method c) Pressure injection treatment method d) Premixing treatment method 3. Microbial geotechnology (Bioclogging and Biocementation) 4. Applications of Bio-Cementation in Construction Practice 5. Challenges of bio-cementing	
Credit II	**Biomass utilization**	15 hours
	1. Biomass Utilization for Biodiesel Production 2. Isolation of the prokaryotic and eukaryotic cellulase genes, manipulation of the cellulase gene, advantages of using *Zymomonasmobilis* 3. Silage production 4. Lignocellulosic Biomass Valorization for Bioethanol Production 5. Biomass utilization for power generation	

Suggested References:

1.Murugan, R., Suraishkumar, G. K., Mukherjee, A., &Dhami, N. K. (2021). Influence of native ureolytic microbial community on biocementation potential of *Sporosarcinapasteurii*. Scientific Reports, 11(1), 20856.

2.Omoregie, A. I., Muda, K., Ong, D. E. L., Ojuri, O. O., Bakri, M. K. B., Rahman, M. R. & Ling, Y. E. (2023). Soil bio-cementation treatment strategies: state-of-the-art review. Geotechnical Research, 40(XXXX), 1-25.
3.Iqbal, D. M., Wong, L. S., & Kong, S. Y. (2021). Bio-cementation in construction materials: a review. Materials, 14(9), 2175.
4.Parmar, S., &Marjadi, D. (2017). Bio cementation: a novel technique and approach towards sustainable material. World Journal of Research and Review, 4(3), 262839.
5.Kumari, S., Kumar, V., Kothari, R., Kumar, P., & Kumar, A. (2022). Biomass Utilization for Biodiesel Production: A Sustainable Technique to Meet Global Fuel Demands and Future Scope. In Biomass, Bioenergy &Bioeconomy (pp. 25-39). Singapore: Springer Nature Singapore.
6.Glick BR, Pasternak JJ. Isolation, characterization and manipulation of cellulase genes. Biotechnol Adv. 1989;7(3):361-86. doi: 10.1016/0734-9750(89)90180-8. PMID: 14542821.
7.Buchholz, S. E., & Eveleigh, D. E. (1990). Genetic modification of *Zymomonasmobilis.* Biotechnology advances, 8(3), 547-581.
8.Devi, A., Bajar, S., Kour, H., Kothari, R., Pant, D., & Singh, A. (2022). Lignocellulosic biomass valorization for bioethanol production: a circular bioeconomy approach. Bioenergy Research, 15(4), 1820-1841.
9.Du, Z., Yang, F., Fang, J., Yamasaki, S., Oya, T., Nguluve, D., ...&Cai, Y. (2023). Silage preparation and sustainable livestock production of natural woody plants. Frontiers in Plant Science, 14.
10. Lal P.B., Wells F.M., Lyu Y., GhoshI.N.Landick R. and Kiley P.J. (2019) A markerless method for genome engineering in *Zymomonasmobilis* ZM4. Front. Microbiol.10: 2216
11. Sarris, D.andPapanikolaou S. Biotechnological production of ethanol: Biochemistry, processes and technologies. Engineering Life Sciences. 16: 307-329
12. Aleid, G. M., Alshammari, A. S., Alomari, A. D., Ahmad, A., Alaysuy, O., & Ibrahim, M.
N. M. (2023). Biomass and domestic waste: a potential resource combination for bioenergy generation and water treatment via benthic microbial fuel cell. *Environmental Science and Pollution Research*, 1-14.

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**CLSI Guidelines**
Course Code:23SMMB39AME	**No. of Credits: 2**
Course Type: PE	**Total Teaching Hours: 30**

Course Objectives	
1.	To guide students about antimicrobial testing.
2.	To teach the role and responsibilities of CLSI.
3.	To make the students aware of guidelines for antimicrobial testing.

Course Outcome	
1.	Students learn about the antimicrobial testing.
2.	Students learn the guidelines for antimicrobial testing.
3.	Students know about the regulatory authorities for antimicrobial testing.

Syllabus		
Credit I	**Antimicrobial Susceptibility testing**	15 hours
	1)Antibacterial susceptibility testing by conventional phenotypic AST methods: (A) Kirby-Bauer agar disc diffusion (B) Agar dilution for the minimum inhibitory concentration (MIC) C) Broth dilution D)Broth microdilution D)Antimicrobial gradient showing minimum inhibitory concentration	
Credit II	**Antifungal Testing**	15 hours
	1. Agar dilution method 2. Broth dilution method 3. Agar overlay method	

Suggested References:

1) Bayot, M. L., & Bragg, B. N. (2019). Antimicrobial susceptibility testing.
2) Salam, M. A., Al-Amin, M. Y., Pawar, J. S., Akhter, N., & Lucy, I. B. (2023). Conventional methods and future trends in antimicrobial susceptibility testing. *Saudi journal of biological sciences*, 103582.
3) Matuschek, E., Copsey-Mawer, S., Petersson, S., Åhman, J., Morris, T. E., &Kahlmeter,

G. (2023). The European committee on antimicrobial susceptibility testing disc diffusion susceptibility testing method for frequently isolated anaerobic bacteria. *Clinical Microbiology and Infection*, *29*(6), 795-e1.

4) Fajt, V. R., & Lubbers, B. V. (2023). Application and Interpretation of Antimicrobial Susceptibility Testing. *Veterinary Clinics: Food Animal Practice*, *39*(1), 115-128.

5) Armengol, E. S., Harmanci, M., &Laffleur, F. (2021). Current strategies to determine antifungal and antimicrobial activity of natural compounds. *Microbiological Research*, *252*, 126867.

6) Yin, D., Guo, Y., Li, M., Wu, W., Tang, J., Liu, Y., ...& Hu, F. (2021). Performance of VITEK 2, E-test, Kirby–Bauer disk diffusion, and modified Kirby–Bauer disk diffusion compared to reference broth microdilution for testing tigecycline susceptibility of carbapenem-resistant *K. pneumoniae* and *A. baumannii* in a multicenter study in China. *European Journal of Clinical Microbiology & Infectious Diseases*, *40*, 1149-1154.

7) Macia, M. D., Rojo-Molinero, E., & Oliver, A. (2014). Antimicrobial susceptibility testing in biofilm-growing bacteria. *Clinical Microbiology and Infection*, *20*(10), 981- 990.

8) Sood, A., Ray, P., &Angrup, A. (2022). Antimicrobial susceptibility testing of anaerobic bacteria: in routine and research. *Anaerobe*, *75*, 102559.

9) Rex, J. H., Pfaller, M. A., Walsh, T. J., Chaturvedi, V., Espinel-Ingroff, A., Ghannoum, M. A & Warnock, D. W. (2001). Antifungal susceptibility testing: practical aspects and current challenges. *Clinical microbiology reviews*, *14*(4), 643-658.

10) Arendrup, M. C., Verweij, P. E., Mouton, J. W., Lagrou, K., &Meletiadis, J. (2017). Multicentre validation of 4-well azole agar plates as a screening method for detection of clinically relevant azole-resistant Aspergillus fumigatus. *Journal of Antimicrobial Chemotherapy*, *72*(12), 3325-3333.

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M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Bio cementing and Biomass utilization**	
Course Code: 23SMMB39BME		**No. of Credits: 2**
Course Type: PE		**Total Teaching Hours: 60**

Course Objectives	
1.	To enrich students' knowledge related to basic concepts of Bio-cementing and Biomass utilization.
2.	To inculcate the concepts of bio-cementing and biomass utilization.
3.	To make students acquainted with the concepts of Bio-cementing and Biomass utilization.

Course Outcome	
1.	Students will understand the concepts of Bio-cementing and Biomass utilization.
2.	Students will be able to study the applications of Bio-cementing**.**
3.	Students will understand the concept challenges of Bio-cementing and Biomass utilization.

Syllabus		
Credit I	**Bio-cementing**	30 hours
	1. Isolation, identification and characterization of biocementation potent microorganisms from different environmental samples. 2. Microbial induced carbonate precipitation (MICP) using a bio-cementation method using ureolytic bacteria.	
Credit II	**Biomass utilization**	30 hours
	1. Biodiesel production using micro-algae 2. Isolation of bio-emulsifier producing organisms	

Suggested References:

1. Ariyanti, D., &Handayani, N. A. (2012). Hadiyanto (2012) Feasibility of Using Microalgae for Biocement Production through Biocementation.J Bioprocess Biotechniq, 2(111),
2. Dubey, A.A., Ravi, K., Mukherjee, A. et al. Biocementation mediated by native microbes from Brahmaputra riverbank for mitigation of soil erodibility. Sci Rep 11, 15250 (2021).
3. L. Cheng, R. Cord-RuwischUpscaling effects of soil improvement by microbially induced calcite precipitation by surface percolation Geomicrobiol. J., 31 (2014), pp. 396-406,
4. Effect of microbial-induced calcite precipitation on surface erosion and scour of granular soils proof of concept J. Transp. Res. Board, 2657 (2017), pp. 10-18, 10.3141/2657-02
5. Gupta G. V. (2016) New and Future Developments in Microbial Biotechnology and Bioengineering.Aspergillus System Properties and Applications. Elsevier Book

M.Sc. Semester III (NEP – Autonomy 2023 Pattern)

Course Title	**Research Project**
CourseCode:23SMMB31RP	**No. of Credits: 4**
Course Type: Int	**Total Teaching Hours:60**

Course Objectives	
1.	To perform systematic and critical investigation of a phenomena.
2.	To be able to learn something new.
3.	To be able to hone problem-solving skills

Course Outcome	
1.	Students will understand how to perform systematic and critical investigation of a phenomena
2.	Students would be able to learn something new.
3.	Students would be able to develop problem-solving skills

1.A dissertation can be carried out by a single student or by a group of students where the group should not contain more than three students.
1.The dissertation report will be prepared as per the thesis format.
2.Submission of the dissertation report will be at least ten days before the date of examination.
3.One copy of the report will be preserved in the department, in college.
5.If there is more than one student carrying out a single dissertation, a single report can be submitted to the department and these students will be assessed based on a single oral presentation.
6.In such a case, the presentation should be carried out by all the students carrying out the same work; dividing the presentation equally among them.
7.At the time of presentation, the external and internal examiners will be present; the dissertation guide may or may not be present.
8.Presentation should be carried out in the presence of an audience composed of examiners, departmental teaching staff and the postgraduate students of the department (M.Sc. I and II).
9.Oral presentation can be carried out using posters, blackboard, transparencies, model or LCD projector.
10.The allotted time for each oral presentation (one project) should be 10 to 12 minutes, followed by a question and answer session of 5 to 8 minutes. The audience can participate in this session.
11.The assessment of the dissertation is for a total of 100 marks (IA-50 and EA-50) out of which end semester will be for 50 marks and the in-semester assessment will be for 50 marks.
12.The assessment of the first 50 marks (in semester) will be carried out by the guide(s) who has supervised the work of the candidate(s) throughout the semester. The assessment will be carried out on the basis of the points, as per the accompanied format of the mark sheet. Head of the department should

communicate this point wise assessment system to the dissertation supervisor, well in advance. Guide(s) will give appropriate marks, point-wise and submit it in a sealed envelope(s) to the Head of the respective department, three days prior to examination and project presentation. On the day of examination, the Head of the department will hand over these unopened envelopes to the examiners.

13.Assessment of remaining 50 marks (end semester examination for both courses) will be carried out for individual students at the time of examination jointly by Internal and External examiners by the means of oral presentation. The assessment will be carried out on the basis of the points as per the accompanied format of the mark sheet.

14.Students should be made aware of the assessment parameters, on which they will be assessed throughout the semester and at the end of the third semester.

15.The external and internal examiners by mutual agreement will appropriately settle the marks given by the guide (reconsider, if necessary) and marks of oral presentation and submit the mark lists to the Chairman of the M. Sc. Examination Panel for that examination.

Course 23SMMB31RP (Research Project)

Month Year

Name of the Center:

Name of the Student:

Exam No.:

Point-wise mark sheet – to be filled in by the Guide (Based on the evaluation carried out throughout the period of dissertation)

Sr. No.	Points for Evaluation	Max. Marks	Evaluation
1.	Intellectual potential – Understanding of the research problem by the student (topic selection)	**08**	
2.	Research aptitude –		
	a) Depth of literature survey for the proposed work.	**05**	
	b) Inputs of student in development of plans and protocols for the experimentation (methodology)	**08**	
	c) Ability to analyze data and formulate a solution (statistical analysis)	**08**	
	d) Analytical and reasoning abilities of the student for interpretation of data, inputs in discussion	**08**	
3.	Motivation – punctuality, meeting dead-lines and seriousness (attendance)	**04**	
4.	Ability to work with others	**04**	
5.	Communication skill – oral and written (conferences, oral, ppt., publication)	**05**	
	Total	**50**	

Place of work:

Name of the Guide:

Date and Signature:

Course 23SMMB31RP (Research Project)

Month:

Year:

Name of the Center:

Name of the Student:

Exam No.:

Point wise mark sheet – to be filled in by External examiner (Based on oral presentation and viva voce of the dissertation as end semester evaluation)

Sr. No.	Points for Evaluation	Max. Marks	Evaluation
1.	Proficiency of presentation skills – use of audio-visual aids, preparation of graphs, charts, models, statistical analysis etc., use of scientific language	7	
2.	Research potential of the work, results and interpretation, outcome of the study and possible future plans, publication potential of the work towards society	7	
3.	The dissertation report preparation (scientific writing) and its contents	4	
4.	Abilities of satisfactory responses to the queries from the audience (defense)	7	
	Total	**25**	

Place of work:

Name of the External Examiner:

Signature:

Date:

Course 23SMMB31RP (Research Project)

Month Year Name of the Center: Name of the Student: Exam No.:

Point wise mark sheet – to be filled in by Internal Examiner (Based on oral presentation and viva voce of the dissertation as end semester evaluation)

Sr. No.	**Points for Evaluation**	**Max. Marks**	**Evaluation**
1.	Proficiency of presentation skills – use of audio-visual aids, preparation of graphs, charts, models, statistical analysis etc., use of scientific language	7	
2.	Research potential of the work, results and interpretation, outcome of the study and possible future plans, publication potential of the work towards society	7	
3.	The dissertation report preparation (scientific writing) and its contents	4	
4.	Abilities of satisfactory responses to the queries from the audience (defense)	7	
	Total	**25**	

MSc II Semester IV NEP Syllabus
M. Sc. Semester IV (NEP – Autonomy 2023 Pattern)

Course Title	**PHARMACEUTICAL MICROBIOLOGY**
Course Code:23SMMB41MM	**No. of Credits: 2**
Course Type: M1	**Total Teaching Hours: 30**

Course Objectives	
1.	To enrich students' knowledge related to basic concepts in drug development. .
2.	To inculcate the knowledge regarding drug designing, pharmacokinetics and pharmacodynamics
3.	To make students acquainted with recent trends of drug repurposing

Course Outcome	
1.	Students will understand the concepts of drug discovery and drug development.
2.	Students will be able to understand pharmacokinetics and pharmacodynamics
3.	Students will understand recent trends of drug repurposing

Syllabus		
Credit I	**Drug Development and Repurposing**	
	A.Introduction to modern drug discovery, rational drug design: Ligand based and receptor-based drug design. (Molecular docking) B.Clinical development: Clinical trials (aims, objectives and conduct). Clinical trials I, II, III and IV C.Drug Repurposing 1. Anticancerous 2.Antipsychotics 3.Antihelminthic 4.Antiinflammatory 5.Statins	15 hours
Credit II	**Pharmacokinetics and Pharmacodynamics**	
	Pharmacokinetics: A.Drug absorption: Drug dosages, from gastric emptying to gastric permeability to drug, first pass effect, bioavailability. B.Drug distribution: Drug-plasma/ serum binding, blood brain barrier, accumulation in tissues. C.Drug Metabolism: Phase I, Phase II, Phase III D.Drug elimination: Drug excretion, Drug biotransformation. **Pharmacodynamics:**	15 hours

	A.Biochemical, physiological and molecular effects of drugs on the body. B.Therapeutic Effect, Neutral and Adverse Drug Reactions	

Suggested References:

1.Brogi, S., Ramalho, T. C., Kuca, K., Medina-Franco, J. L., &Valko, M. (2020). In silico methods for drug design and discovery.Frontiers in chemistry, 8, 612.

2.Inan, O.T., Tenaerts, P., Prindiville, S.A. *et al.* Digitizing clinical trials. *npj Digit. Med.* 3, 101 (2020)

3.AlanTalevi& Carolina L. Bellera (2020) Challenges and opportunities with drug repurposing: finding strategies to find alternative uses of therapeutics, Expert Opinion on Drug Discovery, 15:4, 397-401.

4.Pawar VA, Tyagi A, Verma C, Sharma KP, Ansari S, Mani I, Srivastava SK, Shukla PK, Kumar A, Kumar V. Unlocking therapeutic potential: integration of drug repurposing and immunotherapy for various disease targeting. Am J Transl Res. 2023 Aug 15;15(8):4984-5006. PMID: 37692967; PMCID: PMC10492070.

5.Zhao M, Ma J, Li M, Zhang Y, Jiang B, Zhao X, Huai C, Shen L, Zhang N, He L, Qin S. Cytochrome P450 Enzymes and Drug Metabolism in Humans. Int J Mol Sci. 2021 Nov 26;22(23):12808. doi: 10.3390/ijms222312808. PMID: 34884615; PMCID: PMC8657965.

M.Sc.Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Microbial Technology**
Course Code: 23SMMB42MM	**No. of Credits: 2**
Course Type: M2	**Total Teaching Hours:30**

Course Objectives	
1.	To make students aware of microbial technology and its applications.
2.	To make them familiar with various techniques in fermentation.
3.	To teach them applications of microorganisms in various industries.

Course Outcome	
1.	Students will learn about microbial technology and its applications.
2.	Students will learn about various process control methods in fermentation.
3.	Students will be acquainted with the applications of microorganisms in different industries.

Syllabus		
Credit I	**Bioreactor Design and Operation**	15 hours
	A. Agitation: Functions, Flow patterns and different types of impellers. B. Aeration: Theory of Oxygen transfer in bubble aeration, Oxygen transfer kinetics (OUR, OTR, Ccrit) Determination of KLa C. Mass Transfer of oxygen and nutrients	
Credit II	**Process Variables and Monitoring**	15 hours
	A. Fermentation Broth Rheology and Power requirements for agitation, Concept of Newtonian and Non Newtonian fluids. B. Reynolds Number, Power Number, Aeration Number. Monitoring of process variables: C. Basic principles of operation, types of biosensors D. Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO2)	

Suggested References:

1.Strategy for the design of a bioreactor for L-lysine immobilized fermentation using *Corynebacteriumglutamicum*ApplMicrobiolBiotechnol 2022 Sep;106(17):5449-5458. doi: 10.1007/s00253-022-12103-w. Epub 2022 Jul 29.

2. Gargalo, C. L., Lopez, P. C., Hasanzadeh, A., Udugama, I. A., &Gernaey, K. V. (2022). On-line monitoring of process parameters during fermentation. In current

developments in biotechnology and bioengineering (pp. 117-164). Elsevier.
3. Phillips, J. A. (2020). “Novel” sensors for the monitoring of fermentation processes. In Computer control of fermentation processes (pp. 15-72). CRC Press. https://pubmed.ncbi.nlm.nih.gov/35797907/
4. McDuffie, N. G. (2013). *Bioreactor design fundamentals*. Butterworth-Heinemann.
5. Chisti, Y., & Moo-Young, M. (2006). Bioreactor design. *Basic biotechnology*, 151-72.
6. Aiba S., Humphrey A. E. and Millis N. F. (1982). Biochemical Engineering. Second Edition.Academic Press.
7. Angela Jozala (2017) Fermentation Processes Publisher-BoD.Books on Demand. ISBN- 9535129279, E-Book 9789535129271 3. Carl-Fredrik Mandenius. (2016)
8. Bioreactors: Design, Operation and Novel Applications. Reprint. Publisher-John Wiley & Sons. ISBN 3527683372 E-Book- 9783527683376
9. Larroche C., Sanroman M., Du G. and Pandey A. (Editors). (2016) Current Developments in Biotechnology and Bioengineering: Bioprocesses, Bioreactors and Controls. Publisher-Elsevier, ISBN 0444636749, E- Book9780444636744
10. Stanbury P., Whitaker A. and Hall S. (2016) Principles of Fermentation Technology. 3rd Edition Imprint: Butterworth-Heinemann.
11. Kuila, A., & Sharma, V. (Eds.). (2018). *Principles and applications of fermentation technology*. John Wiley & Sons.
12. Arora, S., Rani, R., &Ghosh, S. (2018). Bioreactors in solid state fermentation technology: Design, applications and engineering aspects. *Journal of Biotechnology*, *269*, 16-34.
13. Wang, B., Wang, Z., Chen, T., & Zhao, X. (2020). Development of novel bioreactor control systems based on smart sensors and actuators. *Frontiers in bioengineering and biotechnology*, *8*, 7.
14. Rathore, A. S., Mishra, S., Nikita, S., &Priyanka, P. (2021). Bioprocess control: Current progress and future perspectives. *Life*, *11*(6), 557.
15. Fitzpatrick, J. J., Gloanec, F., & Michel, E. (2020). Insights from Mathematical Modelling into Process Control of Oxygen Transfer in Batch Stirred Tank Bioreactors for Reducing Energy Requirement. *ChemEngineering*, *4*(2), 34.

M.Sc. Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Applications of Nano biotechnology**
Course Code: 23SMMB43MM	**No. of Credits: 2**
Course Type: M3	**Total Teaching Hours:30**

Course Objectives	
1.	To introduce the concepts of Nanobiotechnology
2.	To make students learn the concepts of nanoparticles and their uses.
3.	To give students the knowledge of the applications of Nano biotechnology in different industries.

Course Outcome	
1.	Students will be acquainted with the concepts of Nanobiotechnology
2.	Students will understand the applications of Nano biotechnology in various fields
3.	Students will get knowledge of Nano carriers, Nano sensors and their uses in different fields.

Syllabus		
Credit I	**Nanobiotechnology in Medicine**	15 hours
	A. Concept of Nanobiotechnology in Nanomedicine B. Two main branches in Nanomedicine: Diagnostics and Therapeutics C. Different Nanoparticles and their Medical applications	
Credit II	**Nanobiotechnology in Food Industry**	15 hours
	A. Food Safety a) Nanoencapsulation b) Food preservation. c) Biosecurity - Food analysis and contaminant detection B. Food Packaging (Nanoscience in Food Packaging) a. Nanopackaging for enhanced shelf life - Smart/Intelligent	

Suggested References:

1. Malik S, Muhammad K, Waheed Y. Emerging Applications of Nanotechnology in Healthcare and Medicine. Molecules. 2023 Sep 14;28(18):6624. doi: 10.3390/molecules28186624. PMID: 37764400; PMCID: PMC10536529.
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M.Sc.Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**CRISPR TECHNOLOGY**
Course Code:23SMMB44MM	**No. of Credits: 2**
Course Type: M4	**Total Teaching Hours:30**

Course Objectives	
1.	To enrich students' knowledge related to basic concepts of CRISPR Technology.
2.	To inculcate the concepts of genome editing tools.
3.	To make students acquainted with the concepts of CRISPR Cas technology.

Course Outcome	
1.	Students will understand the concepts of CRISPR.
2.	Students will be able to study the applications of CRISPR.
3.	Students will understand the concept challenges of CRISPR Technology.

Syllabus		
Credit I	**Previous Genome Editing tools and History of CRISPR**	15 hours
	1. Zing Finger Nucleases 2.Transcription activator-like effector nucleases 3.RNAi 4.DNA repair mechanisms and the history of CRISPR-Cas9 technology development	
Credit II	**Applications of CRISPR-Cas9 tools**	15 hours
	1.Evolution of second-generation CRISPR gene editing tool 2.Transcriptional Modulation. 3. Cas9 protein modifications and orthologs 4.Applications of CRISPR-Cas9 technology 5.Agricultural applications. 6.Challenges of CRISPR-Cas9 applications and paving the way towards precise and safe CRISPR genome editing.	

Suggested References:

1. Dong D, Guo M, Wang S, Zhu Y, Wang S, Xiong Z, Yang J, Xu Z, Huang Z (2017) Structural basis of CRISPR–SpyCas9 inhibition by an anti-CRISPR protein. Nature 546:436–439. https://doi.org/10.1038/ nature2237

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M.Sc. Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Nano Biotechnology and CRISPR Technology**	
Course Code:23SMMB45MP		**No. of Credits: 2**
Course Type: P1		**Total Teaching Hours: 60**

Course Objectives	
1.	To make students aware of Nanobiotechnology
2.	To inculcate the concepts of genome editing tools.
3.	To make students acquainted with the concepts of CRISPR Cas technology.

Course Outcome	
1.	Students will be able to understand Nanobiotechnology
2.	Students will be able to understand the concept of genome editing tools.
3.	Students will understand the concepts and challenges of CRISPR Technology.

Syllabus		
Credit I	**Nanobiotechnology**	30 hours
	1.Use of Nanoparticles for biofilm inhibition and degradation. 2.Preparation of nanocomposites 3. Use of nanoparticles in diagnostics	
Credit II	**CRISPR Technology**	30 hours
	1.Disrupting bacterial gene using CRISPR/Cas9 and observing the resulting phenotypic change 2.Genome editing using CRISPR /cas9 gene	

Suggested References:

1.Shakib, P., Saki, R., Zolfaghari, M. R., &Goudarzi, G. (2023). Efflux Pump and Biofilm Inhibitory Activity of Nanoparticles in Acinetobacter Baumannii: a Systematic Review. *Clinical Laboratory*, *69*(10).

2. Alrushaid N, Khan FA, Al-Suhaimi EA, Elaissari A. Nanotechnology in Cancer Diagnosis and Treatment. Pharmaceutics. 2023 Mar 22;15(3):1025. doi: 10.3390/pharmaceutics15031025. PMID: 36986885; PMCID: PMC10052895.

3. Alavi, M., Li, L., &Nokhodchi, A. (2023). Metal, metal oxide and polymeric nanoformulations for the inhibition of bacterial quorum sensing. *Drug Discovery Today*, *28*(1), 103392.

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9. Cui Y, Wu C, Li L, Shi H, Li C, Yin S. Toward nanotechnology-enabled application of bilirubin in the treatment and diagnosis of various civilization diseases. Mater Today Bio. 2023 May 4;20:100658. doi: 10.1016/j.mtbio.2023.100658. PMID: 37214553; PMCID: PMC10196858

10. Tiwari R, Gupta RP, Singh VK, Kumar A, Rajneesh, Madhukar P, Sundar S, Gautam V, Kumar R. Nanotechnology-Based Strategies in Parasitic Disease Management: From Prevention to Diagnosis and Treatment. ACS Omega. 2023 Nov 1;8(45):42014-42027. doi: 10.1021/acsomega.3c04587. PMID: 38024747; PMCID: PMC10655914.

M.Sc. Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Industrial Microbiology and Applications of Fungi in industry**
Course Code:23SMMB46MP	**No. of Credits: 2**
Course Type: P2	**Total Teaching Hours:60**

Course Objectives	
1.	To learn about industrial Microbiology
2.	To be able to understand large scale production and purification of fungal bioactive compounds
3.	To be able to understand role of fungi in production of enzymes,vitamins,aminoacids,alkaloids,ethanol,organic acids ,antimicrobials,gibberellin and polysaccharides

Course Outcome	
1.	Students will understand about Industrial Microbiology
2.	Students would be able to understand large scale production and purification of fungal bioactive compounds
3.	Apply knowledge about role of fungi in production of enzymes, vitamins, amino acids ,alkaloids, ethanol, organic acids ,antimicrobials, gibberellin and polysaccharides

Syllabus		
Credit I	**Industrial Microbiology**	30 hours
	Large scale production and purification from fungi: 1. Enzymes 2. Vitamins 3. Amino acids 4. Antimicrobials	
Credit II	**Other fungal bioactive compounds**	30 hours
	Large scale production and purification from fungi: 1. Organic acids 2. Alkaloids 3. Ethanol 4. Gibberellin 5. Polysaccharides	

Suggested References:

1.Review A Comprehensive Insight into Fungal Enzymes: Structure, Classification and their role in Mankind's Challenges Hamada El- Gendi, Ahmed K. Saleh, RaiedBadierah, Elrashdy M. Redwan, Yousra A. El- Maradny and Esmail M. El- Fakharany, J. Fungi 2022,8,23.

2.Arnau J, Yaver D, Hjort CM. Strategies and Challenges for the Development of Industrial Enzymes Using Fungal Cell Factories. Grand Challenges in Fungal Biotechnology. 2019 Sep 27:179–210. doi: 10.1007/978-3-030-29541-7_7.

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4.Plant metabolites under environmental stress Mechanisms,responses and adaptation strategies Nivas M Desai,ManasiPatil,Umesh R Pawar CRC Press Taylor and Francis group , Apple Academic Press 2023

M.Sc. Sem IV(NEP – Autonomy 2023 Pattern)

Course Title	**Bioethics and Biosafety**
Course Code:23SMMB47AME	**No. of Credits: 2**
Course Type: E1	**Total Teaching Hours:30**

Course Objectives	
1.	To make students learn about bioethics.
2.	To make them acquainted with the concept of biorisk.
3.	To make students understand biosafety and its principles.

Course Outcome	
1.	Students will get the knowledge of bioethics.
2.	Students will learn the concept of biorisk.
3.	Students will get acquainted about biosafety and its principles.

Syllabus		
Credit I	**Bioethics**	15 hours
	1. Concept of ethics and bioethics with respect to Microbiological research 2. Important ethical terms 3. Analyzing ethical issues 4. Principles of bioethics 5. Ethics and ethical theories 6. Ethical conflicts in Microbiological and Biotechnological research 7. Genetically modified crops and bioethics 8. Bioethics and Reproductive technology 9. Stem cells and bioethics 10. Organ transplant and bioethics 11. Human cloning and bioethics	
Credit II	**Biosafety and biosecurity**	15 hours
	1. Biosafety: a. Concept of Biosafety and Biorisk b. Assessment of risk c. Biohazards d. Laboratory biosafety and biosafety levels e. The Importance of Biocontainment Laboratories **2. Biosecurity:** a. Initial concept and existing definitions b. The Current Understanding and Definition of Biosecurity c. Biosecurity hazards d. Components of protection: physical security, personnel	

	reliability, and information security **3. Regulatory Bodies:** Regulatory bodies (Role and functions) a. Advisory Committee: Recombinant DNA Advisory Committee (RDAC) b. Regulatory / Approval Committees: i. Genetic Engineering Appraisal Committee (GEAC) ii. Review Committee on Genetic Manipulation (RCGM) iii. SIRO (DSIR) iv. Institutional Biosafety Committee (IBSC): Importance of Biosafety Institutional Biosafety Committees (IBSCs) Laboratory associated infections and hazards Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions c. Monitoring Committees: i. State Biotechnology Coordination Committee (SBCC) ii. District Level Committee (DLC)	

Suggested References:

1. Renault, V.; Humblet, M.-F.; Saegerman, C. Biosecurity Concept: Origins, Evolution and Perspectives. Animals 2022, 12, 63. https:// doi.org/10.3390/ani12010063
2. Biotechnology: A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nded) ISBN- 10 3527304320. 2. Encyclopedia of Bioethics 5 vol set, (2003) ISBN-10: 0028657748.
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M.Sc.Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Microbial growth characteristics and Product formulation**
Course Code: 23SMMB47BME	**No. of Credits: 2**
Course Type: E2	**Total Teaching Hours:30**

Course Objectives	
1.	To make students aware of microbial growth and its effect on fermentation.
2.	To make them familiar with various growth forms in fermentation.
3.	To teach them the kinetics of product formation.

Course Outcome	
1.	Students will learn about microbial growth and its effect on fermentation.
2.	Students will learn about various growth forms in fermentation.
3.	Students will be acquainted with the kinetics of product formation.

Syllabus		
Credit I	**Microbial Growth kinetics and product formation**	15 hours
	.A. Control of primary (growth associated) and secondary (growth non-associated) metabolites. B. Kinetics of growth and product formation (growth rate, yield coefficient, efficiency)	
Credit II	**Effect of Type of growth with respect to Mass Transfer on fermentation**	15 hours
	Effect of type of growth on mass transfer of nutrients,oxygen and heat on fermentation - Different types of growth (mycelial form, free cell, cells producing exopolysaccharides)	

Suggested References:

1.Strategy for the design of a bioreactor for L-lysine immobilized fermentation using *Corynebacteriumglutamicum*ApplMicrobiolBiotechnol 2022 Sep;106(17):5449-5458. doi: 10.1007/s00253-022-12103-w. Epub 2022 Jul 29.

2. Gargalo, C. L., Lopez, P. C., Hasanzadeh, A., Udugama, I. A., &Gernaey, K. V. (2022). On-line monitoring of process parameters during fermentation. In current developments in biotechnology and bioengineering (pp. 117-164). Elsevier.

3. Phillips, J. A. (2020). "Novel" sensors for the monitoring of fermentation processes. In Computer control of fermentation processes (pp. 15-72). CRC Press.

4. McDuffie, N. G. (2013). *Bioreactor design fundamentals*. Butterworth-Heinemann.
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8. Bioreactors: Design, Operation and Novel Applications. Reprint. Publisher-John Wiley & Sons. ISBN 3527683372 E-Book-9783527683376
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15. Fitzpatrick, J. J., Gloanec, F., & Michel, E. (2020). Insights from Mathematical Modelling into Process Control of Oxygen Transfer in Batch Stirred Tank Bioreactors for Reducing Energy Requirement. *ChemEngineering*, *4*(2), 34.
16. Biswas J. and Paul A. K. (2017). Optimization of factors influencing exopolysaccharide production by Halomonasxianhensis SUR308 under batch culture. AIMS Microbiology, 3(3),564– 579.
17. Hereher F., El-fallal A. and Abou-Dobara M. (2018). Cultural optimization of a new exopolysaccharide producer “Micrococcus roseus”. Beni-Suef University Journal of Basic and Applied Sciences. 7(4): 632-639
18. Maia P., Santos V., Ferreira A., Luna M., Silva T., Andrade R. and Campos T. G. (2018). An efficient bioemulsifier-producing Bacillus subtilis UCP 0146 isolated from mangrove sediments.Colloids and Interfaces. 2. 58. 10.3390/colloids2040058

M.Sc. Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Quality assurance in pharmaceutical industry**
Course Code:23SMMB48AME	**No. of Credits: 2**
Course Type: E3	**Total Teaching Hours:30**

Course Objectives	
1.	To make students understand GLP and GMP in pharmaceutical industry
2.	To make them understand the certification processes in the pharmaceutical industry.
3.	To inculcate the knowledge of assessment of pharmaceutical quality.

Course Outcome	
1.	The students will understand the concepts of GLP and GMP in pharmaceutical industry
2.	They will learn the certification processes in the pharmaceutical industry.
3.	They will get the knowledge of assessment of pharmaceutical quality.

Syllabus		
Credit I	**GLP and GMP**	**15 hours**
	1. Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry. 2. ISO, WHO and US certification. 3. Defining and accessing pharmaceutical quality 4. Consequences of poor pharmaceutical quality and obtaining good quality 5. ICH Guidelines: purpose, participants, process of harmonization, Brief overview of QSEM with special emphasis on Q-series guidelines, ICH stability testing guidelines Quality by design (QbD): Definition, overview, elements of QbD program, tools ISO 9000 & ISO14000: Overview, Benefits, Elements, steps for registration 6. 7. NABL accreditation : Principles and procedures	
Credit II	**Assessment of pharmaceutical quality:**	**15 hours**
	a. Quality Control: Quality control test for containers, rubber closures and secondary packing materials. b. General Provisions, Organization and Personnel, Facilities, c. Equipment, Testing Facilities Operation, Test and Control Articles, Protocol for Conduct of a d. Nonclinical Laboratory Study, Records and Reports, Disqualification of Testing Facilities e. Complaints: Complaints and evaluation of	

	complaints, Handling of return good, recalling and waste disposal. f. Document maintenance in pharmaceutical industry: Batch Formula Record, Master Formula g. Record, SOP, Quality audit, Quality Review and Quality documentation, Reports and documents, distribution records. Warehousing: Good warehousing practice, materials management	

Suggested References:

1. Quality assurance of pharmaceuticals A compendium of guidelines and related materials Volume 2, 2nd updated edition Good manufacturing practices and inspection World Health Organization.
2. A Significance and Role of Quality Assurance in Pharmaceutical Industries Shilpa Khambete, International Journal of Research Publication and Reviews, Vol 4, no 12, pp 403-407 December 2023
3. Haleem, R. M., Salem, M. Y., Fatahallah, F. A., &Abdelfattah, L. E. (2015). Quality in the pharmaceutical industry–A literature review. *Saudi pharmaceutical journal*, *23*(5), 463-469.
4. Agarwal, S. (2023). Quality Assurance: Role in the Pharmaceutical Industry. *International Journal of Pharmaceutical Sciences and Nanotechnology (IJPSN)*, *16*(5), 6999-7003.

M.Sc. Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Microbial Waste Management**
Course Code: 23SMMB48BME	**No. of Credits: 2**
Course Type: E4	**Total Teaching Hours:30**

Course Objectives	
1.	To make students aware of types of solid and liquid wastes.
2.	To make them familiar with various techniques of solid and liquid waste management.
3.	To teach them the role of microorganisms in waste management.

Course Outcome	
1.	Students will learn about the methodology of waste management.
2.	Students will learn about current trends in waste management.
3.	Students will be acquainted with the role of microorganisms in waste management.

Syllabus		
Credit I	**Types of solid waste and its management**	15
	Unit I: Types of solid waste:	5
	1. Biodegradable and non-biodegradable waste 2. Municipal solid waste 3. Agricultural waste 4. Industrial solid waste 5. Radioactive waste 6. E-waste Effects of Solid Waste on Environment & Human Health	
	Unit II: Solid Waste management	10
	1. Use of microorganisms in waste management: Bacteria, Fungi, algae, virus, protozoa 2. Landfill technology: 3. Bioreactor landfills a. Anaerobic bioreactor landfills b. Aerobic bioreactor landfills c. Landfills with semi-aerobic bioreactors 4. Composting 5. Microbial degradation of plastic 6. E-waste management 7. Radioactive waste management 8. Waste management system 9. Challenges to solid waste management	

Credit II	**Types of liquid waste and its management**	
	Unit I: Types of liquid waste	5
	1. Industrial waste 2. Domestic waste 3. Hospital waste 4. Agricultural waste 5. Characteristics of waste	
	Unit II: Liquid waste management	10
	1. Autothermalthermophilic aerobic digestion **2.** Microbial biofilm reactor **3.** Immobilized microbial nanoparticles and nanofiltration **4.** Role of Microalgae in removal of organic matter from waste water **5.** Fungi based waste water treatment **6.** Bacteriophages in waste water treatment	

Suggested References:

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M.Sc. Sem IV (NEP – Autonomy 2023 Pattern)

Course Title	**Research Project**		
Course Code: 23SMMB41RP			**No. of Credits: 6**
Course Type: Int			**Total Teaching Hours: 90**

Course Objectives	
1.	To perform systematic and critical investigation of a phenomena.
2.	To be able to learn something new.
3.	To be able to hone problem-solving skills

Course Outcome	
1.	Students will understand how to perform systematic and critical investigation of a phenomena
2.	Students would be able to learn something new.
3.	Students would be able to develop problem-solving skills

1. A dissertation can be carried out by a single student or by a group of students where the group should not contain more than three students.
2. The dissertation report will be prepared as per the thesis format.
3. Submission of the dissertation report will be at least ten days before the date of examination.
4. One copy of the report will be preserved in the department, in college.
5. If there is more than one student carrying out a single dissertation, a single report can be submitted to the department and these students will be assessed based on a single oral presentation.
6. In such a case, the presentation should be carried out by all the students carrying out the same work; dividing the presentation equally among them.
7. At the time of presentation, the external and internal examiners will be present; the dissertation guide may or may not be present.
8. Presentation should be carried out in the presence of an audience composed of examiners, departmental teaching staff and the postgraduate students of the department (M.Sc. I and II).
9. Oral presentation can be carried out using posters, blackboard, transparencies, model or LCD projector.
10. The allotted time for each oral presentation (one project) should be 10 to 12 minutes, followed by a question and answer session of 5 to 8 minutes. The audience can participate in this session.
11. The assessment of the dissertation is for a total of 150 marks (IA-75 and EA-75) out of which end semester will be for 75 marks and the in-semester assessment will be for 75 marks.
12. The assessment of the first 75 marks (in semester) will be carried out by the guide(s) who has supervised the work of the candidate(s) throughout the semester.

The assessment will be carried out on the basis of the points, as per the accompanied format of the mark sheet. Head of the department should communicate this point wise assessment system to the dissertation supervisor, well in advance. Guide(s) will give appropriate marks, point-wise and submit it in a sealed envelope(s) to the Head of the respective department, three days prior to examination and project presentation. On the day of examination, the Head of the department will hand over these unopened envelopes to the examiners.

13. Assessment of remaining 75 marks (end semester examination for both courses) will be carried out for individual students at the time of examination jointly by Internal and External examiners by the means of oral presentation. The assessment will be carried out on the basis of the points as per the accompanied format of the mark sheet.
14. Students should be made aware of the assessment parameters, on which they will be assessed throughout the semester and at the end of the fourth semester.
15. The external and internal examiners by mutual agreement will appropriately settle the marks given by the guide (reconsider, if necessary) and marks of oral presentation, and submit the mark lists to the Chairman of the M. Sc. Examination Panel for that examination.

Course 23SMMB41RP (Research Project)

Month
Year Name of the Center:
Name of the Student:
Exam No.:
Point-wise mark sheet – to be filled in by the Guide (Based on the evaluation carried out throughout the period of dissertation)

Sr. No.	Points for Evaluation	Max. Marks	Evaluation
1.	Intellectual potential – Understanding of the research problem by the student (topic selection)	**12**	
2.	Research aptitude –		
	a) Depth of literature survey for the proposed work.	**08**	
	b) Inputs of student in development of plans and protocols for the experimentation (methodology)	**11**	
	c) Ability to analyze data and formulate a solution statistical analysis)	**11**	
	d) Analytical and reasoning abilities of the student for interpretation of data, inputs in discussion	**11**	
3.	Motivation – punctuality, meeting dead-lines and seriousness (attendance)	**08**	
4.	Ability to work with others	**07**	
5.	Communication skills – oral and written (conferences, oral, ppt., publication)	**07**	
	Total	**75**	

Place of work :
Name of the Guide:
Date and Signature:

Course 23SMMB41 RP (Research Project)

Month **Year**

Name of the Center:

Name of the Student:

Exam No.:

Point wise mark sheet – to be filled in by External examiner (Based on oral presentation and viva voce of the dissertation as end semester evaluation)

Sr. No.	**Points for Evaluation**	**Max. Marks**	**Evaluation**
1.	Proficiency of presentation skills – use of audio-visual aids, preparation of graphs, charts, models, statistical analysis etc., use of scientific language	11	
2.	Research potential of the work, results and interpretation, outcome of the study and possible future plans, publication potential of the work towards society	11	
3.	The dissertation report preparation (scientific writing) and its contents	7	
4.	Abilities of satisfactory responses to the queries from the audience (defense)	11	
	Total	**40**	

Place of work:

Name of the External Examiner:

Signature:

Date:

Course 23SMMB41RP (Research Project)

Month: **Year:**

Name of the Center:

Name of the Student:

Exam No.:

Point wise mark sheet – to be filled in by Internal Examiner (Based on oral presentation and viva voce of the dissertation as end semester evaluation)

Sr. No.	**Points for Evaluation**	**Max. Marks**	**Evaluation**
1.	Proficiency of presentation skills – use of audio-visual aids, preparation of graphs, charts, models, statistical analysis etc., use of scientific language	9	
2.	Research potential of the work, results and interpretation, outcome of the study and possible future plans, publication potential of the work towards society	9	
3.	The dissertation report preparation (scientific writing) and its contents	8	
4.	Abilities of satisfactory responses to the queries from the audience (defense)	9	
	Total	**35**	

Place of work:

Name of the Internal Examiner:

Signature:

Date: