ANNAMALAI UNIVERSITY

(Accredited with 'A' Grade by NAAC)

FACULTY OF AGRICULTURE

(Accredited by ICAR)

DEPARTMENT OF MICROBIOLOGY

Academic Regulations and Syllabi

DOCTOR OF PHILOSOPHY IN MICROBIOLOGY

Under Choice based credit system (CBCS) with Outcome based Education

2022-2023 Onwards

COMMON REGULATIONS FOR ALL Ph.D. PROGRAMMES OF FACULTY OF AGRICULTURE

(w.e.f. 2022-2023)

1. DEFINITIONS

1.1 An **"Academic year"** shall consist of two semesters.

1.2 **"Semester"** means an academic term consisting of 110 instructional days excluding final theory examinations.

1.3 **"Course"** means a unit of instruction to be covered in a semester having specific No., title and credits.

1.4 **"Credit hour"** means, one hour lecture plus two hours of library or homework or two and half hours of library/field practical per week in a semester.

1.5 **"Credit load"** of a student during a semester is the total number of credits registered by that student during that particular semester.

1.6 "**Grade Point"** of a course means the value obtained by dividing the percentage of marks earned in a course by 10 and the Grade Point is expressed on a 10 point scale and rounded off to two decimal places.

1.7 **"Credit Point"** means the grade point multiplied by corresponding credit hours.

1.8 **"Grade Point Average (GPA)"** means the quotient of the total credit points obtained by a student in various courses at the end of each semester, divided by the total credit hours taken by the student in that semester. The grading is done on a 10 scale and the GPA has to be corrected to two decimals.

1.9 **"Overall Grade Point Average (OGPA)"** means the quotient of cumulative credit points obtained by a student in all the courses taken from the beginning of the first semester of the year divided by the total credit hours of all the subjects which he/she had completed up to the end of a specified semester and determines the overall performance of a student in all subjects during the period covering more than one semester. The OGPA has to be arrived at the second decimal place.

2. SYSTEM OF EDUCATION

2.1 These rules and regulations shall govern the Ph.D. programmes leading to the award of Degree of Doctor of Philosophy in the concerned subject in the Faculty of Agriculture, Annamalai University. They shall come into force with effect from the academic year 2022-2023.

2.2 The semester system shall be followed for all the Ph.D. degree programmes. The duration of doctoral programmes is as follows:

2.2.1 The duration of the programme and the time for admission of thesis are counted from the date of provisional registration.

2.2.2 The minimum duration of the programme is three years and the maximum duration of the programme shall be seven years.

2.2.3 Break of study shall be granted up to a maximum period of one year and it can be done only after completing the course work. Such request shall be made in advance by scholar in writing with the recommendation of Supervisor, Head of the Department (HoD) and Dean, Faculty of Agriculture and it should reach the Director, Directorate of

Academic Research (DARE). The orders for the break of study shall be issued by the Director, DARE after assessing the need.

2.2.4 If prior permission is not sought and obtained, it will be considered as a case of discontinuation and action will be taken to cancel the registration of such scholars.

2.2.5 The scholars should remit the yearly fees during the break of study also.

3. PROGRAMMES OFFERED

The details of various Ph.D. programmes offered in the Faculty of Agriculture are as follows:

1. Agri Business Management
2. Agricultural Economics
3. Entomology
4. Agricultural Extension Education
5. Agricultural Microbiology
6. Agronomy
7. Genetics and Plant Breeding
8. Horticulture in Fruit Science
9. Horticulture in Vegetable Science
10. Horticulture in Floriculture and Landscaping
11. Horticulture in Plantation, Spices, Medicinal and Aromatic plants
12. Molecular Biology and Biotechnology
13. Plant Pathology
14. Seed Science and Technology
15. Soil Science

4. ELIGIBILITY FOR ADMISSION

Candidates seeking admission to Ph.D. programme should satisfy the following requirements.

4.1 Candidates with two year master's degree programmes from Universities recognized by Annamalai University are eligible to apply for Ph.D. programmes of the university (Table 1).

4.2 Candidates who have undergone the programme under conventional system should possess not less than a second class Master's degree. The candidates under trimester system should possess a minimum OGPA of 3.00 out of 4.00. For those under semester system 7.00 out of 10.00 is required for various Doctoral programmes.

Table 1: Eligibility Criteria

Doctoral Degree Programmes	Eligibility
1. Agri Business Management	MBA in Agribusiness / MBA Agri Business Management
2. Agricultural Economics	M.Sc. (Ag.) in Agrl. Economics / Agricultural Marketing Management
3. Entomology	M.Sc. (Ag.) in Entomology / Agricultural Entomology

4. Agricultural Extension Education	M.Sc. (Ag.) in Agricultural Extension / Agricultural Extension and Communication / Agricultural Extension Education / Extension Education
5. Agricultural Microbiology	M.Sc. (Ag.) in Agricultural Microbiology
6. Agronomy	M.Sc. (Ag.) in Agronomy
7. Genetics and Plant Breeding	M.Sc. (Ag.) in Genetics and Plant Breeding
8. Horticulture	M. Sc (Ag.) Hort. / M.Sc. (Hort.) / M.Sc. (Hort.) in Fruit Science / Vegetable Science / Floriculture and Landscape Gardening or Architecture / Plantation, Spices, Medicinal and Aromatic Crops
9. Plant Molecular Biology and Biotechnology	M.Sc. (Ag.) in Plant Molecular Biology / Agricultural Biotechnology
10. Plant Pathology	M.Sc. (Ag.) in Plant Pathology
11. Seed Science & Technology	M.Sc. (Ag.) in Seed Science & Technology
12. Soil Science	M.Sc. (Ag.) in Soil Science

4.3 All research scholars shall undergo course work for two semesters as prescribed by the Department. Duration of the programme will be for three years.

4.3.1 The Ph.D. scholars shall report in the Department and sign every day in the attendance register. In order to promote quality research and training in cutting edge areas, the University may permit the scholar to pursue his research work in Annamalai University or in other Universities/Research Institutes by entering with/without MOU between Annamalai University and the partner University/Institute after the completion of qualifying Viva voce examination.

4.3.2. Project staff/ fellow working in projects in the University, sponsored by Government of India/ Industries / Government of Tamil Nadu can also register.

4.3.3. Candidates in employment should be sponsored by their employer and should avail leave for the minimum duration of the programme and should be formally relieved from their duty to register.

4.3.4. Candidates who are selected under the national level fellowship programmes or by any recognized bodies and who satisfy the eligibility conditions as per the regulations shall apply in the respective discipline.

4.3.5. Admission to Foreign Students: Foreign students, who are selected under various scholarship schemes, either by the Ministry of Education and Culture or by the Ministry of External Affairs, will be given admission on the recommendation / sponsorship of the respective Ministry of Government of India. The other foreign students who seek admission should possess a research VISA issued by the Indian Embassies aboard and produce "No Objection Certificate" from the Ministry of Human Resource Development, Government of India, after clearance from the Ministry of External Affairs. They should also show proof for financial capability for staying, pursuing Ph.D. programme for three years.

5. MODE OF SELECTION

5.1. University shall issue notification for Ph.D. admission once in a year.

5.2. The candidates desirous of registering for Ph.D. programme shall apply by filling all the relevant details mentioned in the online application form posted in the University website and submit completed application online before the due date as indicated in the notification issued from time to time.

5.3 Incomplete applications and applications with false information in any respect shall be summarily rejected without any intimation to the candidate.

5.4. The Departmental Research Committee (hereafter referred to as DRC) of concerned Department shall screen the applications as per the eligibility norms and shall conduct the written test and interview only for eligible candidates.

5.5. The admission to Ph.D. students shall be based on the following criteria besides general eligibility.

5.5.1 An entrance test at post graduate level for 70 marks (70 multiple choice questions (MCQs), each question carrying one mark and duration of the test is 90 minutes followed by an interview that will have a weightage of 30 marks.

5.5.2 The candidates who secure 50% marks in entrance test and interview are eligible for admission.

5.5.3 A relaxation of 5 % marks (from 50 % to 45%) shall be allowed for the candidates belonging to SC/ST/OBC (non creamy layer)/ differentially able category.

5.5.4 Candidates with UGC- JRF / NET / ICAR/ICSSR qualified candidates and teacher fellowship holders are exempted from the Entrance test but they have to appear for the interview and evaluated for 100 marks.

5.6 Departmental Research Committee: The following is the constitution of the DRC. The members other than Head of the Department shall serve only for one academic year.

Designation	**Members**
Head of the Department	Convener
Two professors/ Senior Faculty nominated by the Vice-Chancellor in rotation	Members
One Associate Professor (in rotation)	Member
One Assistant Professor (in rotation)	Member

5.7. The DRC has the following functions

5.7.1 Selection of candidates for admission to the Ph.D. programme.

5.7.2 Facilitating research facilities in the Department.

5.7.3 Maintenance of research quality and quality of publications.

5.7.3 Sorting out any other research related issue of the Department.

5.8. If there is any dispute either in the constitution of functioning of the DRC, it shall be brought to the notice of the Director, DARE and the decision of the Vice-Chancellor shall be final.

5.9. The minutes of the DRC together with the list of selected candidates and their research supervisors along with recommendations of the Dean of the respective faculty will be placed before the Vice-Chancellor for approval.

6. ADMISSION

6.1. The selected candidates shall be issued admission cards and they will be admitted to Ph.D. programme in the respective Department based on his/her PG qualification, entrance and interview.

6.2. The provisional registration order for Ph.D. shall be issued to the candidates.

6.3. The scholar, supervisor, Research Advisor Committee members and examiners shall not be relatives to one another.

7. TUITION FEES AND OTHER FEES

7.1 The selected candidates shall pay the prescribed fees before the last date mentioned in the selection order, failing which they will forfeit the seats.

7.2. The yearly fees shall be paid by the scholars within the prescribed date till the scholar submits the thesis. The supervisors should monitor the regular payment of yearly fees by those scholars who are working under them.

7.3. The registration is liable for cancellation, if the research scholar has not paid the yearly fees within stipulated time.

7.4 Non-payment of yearly fees is a serious lapse on the part of the scholars. Explanation for non-payment of yearly fees shall be called for from the supervisors.

7.5 The various fees payable by the students will be decided by the university from time to time.

7.6 Admission to the hostel will be strictly restricted to the actual accommodation available and no associate will be allowed. A Ph.D. student may be allowed to stay in the hostel for a maximum of five years from the date of admission to the Ph.D. programme.

8. CREDIT GRADE POINT REQUIREMENTS

8.1. A student enrolled for Doctoral program is required to complete 100 credits inclusive of 75 credits of research to become eligible for the degree as detailed below:

Sl. No.	Details	Credit Hours
1	Major Courses	12
2	Minor Courses	6
3	Supporting Courses	5
4	Seminar	2
5	Research	75
	Non credit Compulsory courses	
	Research and Publication Ethics (Contact hours: 2) MOOC (Contact hours: 2)	
	Total	**100**

8.2. In a semester, a Ph.D. scholar can register a maximum of 15 credits excluding research. However, the research credits registered should not exceed 16 per semester. Semester-wise distribution of credits is given in the respective Ph.D. programmes.

8.3. Registration Card: A student shall register the courses offered in a semester by writing all the courses in registration card in quadruplicate. The Supervisor, Ph.D. Coordinator and Head of the Department are responsible to furnish the registration particulars of the students with their signature in the Registration card to the Dean. The Dean shall approve the registration cards. The approved registration cards shall be maintained by the HoD, Supervisor and the student concerned. The list of courses registered by the students in each semester shall be sent by the Dean to the DARE for preparation of Report Cards.

8.4. The Ph.D. students should complete their course work within the first two semesters in Annamalai University campus.

8.5. Requirements for Ph.D. programme shall also include successful completion of Non-Credit Compulsory Courses, thesis research in the major field of study and submission of thesis thereon.

9. ATTENDANCE REQUIREMENT

9.1 One hundred per cent attendance is expected from each scholar. A student who fails to secure 80 per cent of attendance in each subject separately for theory and practical, shall not be permitted to appear for the final examination in that subject and shall be awarded 'E' (incomplete) and will be required to repeat the course whenever offered.

9.2 In respect of the student who has absented himself / herself for classes with or without valid reasons, that period will be treated as absence only and not as leave. Also, no attendance will be given for writing make up tests.

9.3 In case of new admission, for calculating 80 percent attendance in the first semester, the number of working days will be calculated from the date of joining of the students who are permitted to join late due to administrative reasons. However, for genuine reasons, condonation of attendance deficiency may be considered by the Vice - Chancellor on the recommendation of the Research Advisory Committee, HoD and Dean, Faculty of Agriculture on payment of condonation fee prescribed by the university.

9.4 Students absenting from the classes with prior permission of the HoD on official University business shall be given due consideration in computing attendance.

9.5 In respect of students who had absented for the mid-semester examination (MSE) on university business with prior permission of the HOD and Dean, Faculty of Agriculture, the makeup first test should be conducted ordinarily within 15 working days from the date of conduct of the first test.

9.6 The students who absent himself/herself for first test in a subject on genuine reasons shall be permitted on the recommendation of the course teacher / Research Supervisor and Head of the Department concerned. Missing examination should be completed within 15 working days from the date of respective examination on payment of missing examination fee prescribed by the university.

10. RESEARCH ADVISORY COMMITTEE

10.1 Each Ph.D. scholar shall have a Research Advisory Committee (RAC) to guide the scholar in carrying out his/her programme.

10.2 A Research Advisory Committee shall be constituted with the approval of the University for each candidate separately, immediately after his/her admission. The purpose of the RAC is to provide expert opinion on frontline research.

10.3 There shall be a Research Advisory Committee for every student consisting of not fewer than four members with the Supervisor as Chairperson. The Research Advisory Committee should have representatives from the major and minor fields. The major **Advisor/Research Advisor** will be from Annamalai University and Co-Research Supervisor will be from the partner institutes (Research Scholars pursuing in other institutes/universities) besides RAC members.

The Research Supervisor should convene a meeting of the Research Advisory Committee at least once in a semester. The research credit evaluation form should be communicated to the Head of Department and the Director, DARE for information.

10.4 **Research Supervisor**

10.4.1 Every scholar shall have a Research Supervisor (among the recognized guides), who will be appointed by the Vice-Chancellor on the recommendation of the DRC, Head of the Department and the Dean, Faculty of Agriculture. Research supervisors approved by the Vice-Chancellor only can be the guide for the students.

10.4.2 A teacher having Ph.D. with 5 years of service and PG teaching is eligible for teaching and guiding Ph. D. scholars. A teacher should have a minimum of three years of service before retirement for allotment of doctoral candidates.

10.4.3 The research supervisors who wish to avail leave/lien/deputation beyond a period of six months shall propose a Co-supervisor in the concerned subject for the candidates registered with them and it may be intimated to the University well in advance. The final approval of the proposal rests with the Vice-Chancellor.

10.5 **Functions of the RAC**:

10.5.1 Discuss, advice and recommend on all matters connected with the scholar's research from admission till the completion of the programme.

10.5.2 Approve the topic of research and the synopsis.

10.5.3 Assess and approve the progress reports of Ph.D. scholars in the prescribed format and to report to the University on the fitness or otherwise of the candidate to proceed with his/her research work for the Ph.D.

10.5.4 If necessary, recommend and approve change of title of dissertation / thesis and change of Research Supervisor.

10.5.5. Conduct the pre-submission presentation (before the submission of synopsis) and to give a certificate to this effect to be submitted along with the synopsis.

10.6 The Research Advisory Committee will meet every semester

10.6.1 To scrutinize the research proposal / progress report submitted by the research scholar.

10.6.2 To assess the conduct of experiments / field work, peruse laboratory notebooks, data recording, analysis, and publication.

10.6.3 To review and endorse the annual progress report of the research scholar.

10.6.4 To approve the synopsis of the thesis.

10.6.4 The Chairperson will convene the Research Advisory Committee meetings with intimation to the Director, DARE through the Head of the Department.

10.7 **Changes in RAC**

The proposals for changes in the RAC are to be sent to the Director, DARE, through HOD and Dean for approval, if it is keenly felt that such changes are absolutely necessary.

10.8 **Change of Research Supervisor**

10.8.1 Change of Research Supervisor shall not be permitted as a routine. In exceptional cases, such change may be permitted, if valid reasons are provided by the candidates. The Committee headed by the Vice-Chancellor shall look into the request of the petitioner, if there is any conflict between the scholar and the research supervisor.

10.8.2 The Research Supervisor under whom the scholar has originally registered shall give a "No Objection Certificate" and the new proposed Research Supervisor should give a "Certificate of Willingness" to guide the candidate. The final decision will rest with the University. However, the Vice-Chancellor, on the recommendation of the RAC and Dean's Committee, has the right to assign a new research supervisor to the research scholar.

10.8.3 When the change of Research Supervisor is approved, the candidate shall work for a minimum of one year with the new Research Supervisor, if the topic of his/her research is different under the new supervisor, provided he/she fulfils the attendance requirements.

10.9 **Change of Topic of Research**

10.9.1 Change of the specific area of research may be permitted within one year from the date of admission and request must be submitted with the recommendations of the RAC. In such cases, the minutes of the RAC meeting must include whether the course work undertaken by the research scholar is relevant to the new research area and the competence of the research supervisor in this field.

10.9.2 If the RAC is of the view that there is a major change in the specific area of research and is not relevant to the course work undertaken, the research scholar will have to go through the process of fresh examination pertaining to the area of research.

10.10 Absence of Member during Qualifying / Final Viva-Voce Examination

Under extra-ordinary circumstances if the qualifying / final viva-voce examination to Ph.D. student has to be conducted in the absence of one or two RAC members, permission to conduct the examination by co-opting another member in such contingencies should be obtained from the Director, DARE in advance.

11. EVALUATION OF STUDENT'S PERFORMANCE

All students shall abide by the rules for evaluating the course work under the semester system of education, as prescribed from time to time by the University.

12. EXAMINATIONS

12.1 There will be two examinations *viz.*, first test and final examination. Wherever the

course has practical, there will be a final practical examination also.

12.2 The duration of first test will be of one and half an hour and final examinations in theory and practical will be conducted for three hours each.

12.2.1 The first test will be conducted by course teachers during the ninth week of the semester as per the scheme drawn by HOD, evaluate and send the marks obtained by the students to the Director, DARE through HOD within seven working days.

12.2.2. The question paper for the final examination will be set as per Bloom's taxonomy by the concerned course teacher in consultation with the Head of the Department.

12.2.3 There will be final examination separately for theory and practical which will be conducted by the University. Each final theory and practical examinations will be evaluated by two examiners (one will be the course teacher and another will be the senior faculty of the Department).

The distribution of marks will be as indicated below:

S. No	Examination	Course with practical	Course without practical	Course without theory
1	First Test	30	30	30
2	Final theory	40	70	-
3	Final practical	30	-	70
	Total	**100**	**100**	**100**

The question paper model and distribution of marks for first test and final theory examinations are as follows:

First Test (30 marks) (1.5 hours duration)

1	Definitions/concepts	5 out of 7	(5 x 1)	5 marks
2.	Short notes	5 out of 7	(5 x 3)	15 marks
3	Essay type	2 out of 3	(2 x 5)	10 marks

Final Theory: Course without practical (70 marks) (3 hours duration)

1.	Short notes	5 out of 7	(5 x 4)	20 marks
2	Essay type	5 out of 7 (four questions must represent K6 level of Bloom's taxonomy)	(5 x 10)	50 marks

Final Theory: Course with Practical (40 marks) (3 hours duration)

1.	Short notes	5 out of 7	(5 x 2)	10 marks
2	Essay type	5 out of 7 (four questions must represent K6 level of Bloom's taxonomy)	(5 x 6)	30 marks

12.3 **Minimum Marks for Pass**

12.3.1 The student should secure a minimum of 60 per cent marks separately in the theory and practical and an aggregate of 70 per cent to secure a pass in the subject. Each subject shall carry a maximum of 100 marks for purpose of grading. The grading will be done as grade point, i.e., the percentage of marks earned in a subject is divided by 10. The grade point is expressed on a 10 point scale upto two decimals.

12.3.2 Students who secure marks below 70 per cent in a subject will be awarded 'RA' grade and students without having the required minimum attendance of 80 per cent will not be allowed to write the final examination and they will be awarded 'E' grade. Students who secure 'RA' grade should appear for re-examination in the subsequent semester. If a student secured 'E' grade, he/she has to re-register and attend the course again during the next academic year.

12.4 **Minimum GPA Requirement**

A Ph. D. student, to continue his/her studies in the University, should maintain certain minimum Average Grade Point prescribed here under:

a) Earn a Grade Point of 7.00 for a pass in each subject.
b) For purpose of continuing as a student in the university, a candidate is required to earn a Grade Point Average of not less than 7.50 at the end of each semester.
c) A Ph.D. student may repeat the course (s) in which he/she gets a Grade Point below 7.50 and above 7.0 to improve the OGPA.

12.5 Re-Examination

12.5.1 Re-examination is permitted only for the final theory and practical examinations. The students who secure 'RA' grade are permitted to write the re-examinations as and when conducted with the permission of university.

12.5.2 The re-examination fee as prescribed by university per course is to be paid on or before the prescribed date. A student is permitted to write the final theory and practical examinations only two times during the course period of three years excluding the regular final examination.

12.5.3 In the event of a student who fails to secure a pass in the two re-examinations permitted, he/she has to re-register for the course along with juniors. The marks secured in first test will be retained and the student should produce the practical record during re-examination. The registration for the re-examination shall be done after first test on the date specified by the Director, DARE. Each registration is considered as an attempt even if the student absents for the examination.

12.6 Return of Valued Answer Papers

12.6.1 The valued answer papers of first test shall be shown to the students after the examination. Discrepancies if any, in awarding marks, the student can approach the teacher concerned immediately for rectification.

12.6.2 The answer paper should be retained with the course teacher for six months and then disposed off. Evaluated final theory papers have to be retained up to six months by the Director, DARE after the conduct of examination and then disposed off.

13. SEMINAR

Seminar is compulsory for all students and each student should register and present two seminars each with 0+1 credits. A student can register only one seminar in a semester and only after successful completion of the first seminar, the student is permitted to register for the second seminar.

13.1 Seminar Topic

13.1.1 The seminar topic should be only from the major field and should not be related to the area of thesis research. The seminar topics are to be assigned to the students by the Research Supervisor in consultation with HOD within three weeks after commencement of the semester.

13.1.2 Under the guidance and supervision of the Research Supervisor of the RAC, the student should prepare a seminar paper containing not less than 50 typed and printed pages with a minimum number of 75 references covering the recent 10 years time after reviewing all the available literature and present the seminar after completion of 80% attendance in the semester in the presence of the HoD, RAC, staff and post-graduate students of the concerned department.

13.1.3 The circular on the presentation of the seminars may be sent to other Departments to enable those interested to attend the same. The Research Supervisor will monitor the progress of the preparation of the seminar and correct the manuscript.

13.1.4 The student will submit two copies of the corrected manuscript to the HOD through Research Supervisor before presentation. The student will incorporate the suggestions and carry out corrections made during the presentation and resubmit three fair copies to the HOD (one to Dept. library, the second to the Research Supervisor and the third for student) within 15 days after presentation.

13.1.5 The performance of the student in the credit seminar will be evaluated and grade point awarded by the HOD along with the RAC for 100 marks. Grade Point may be given based on the following norms

Details	Marks
Coverage of literature	40
Presentation	30
Use of audio-visual aids	10
Capacity to participate in discussion and answer the questions	20
Total	**100**

14. QUALIFYING EXAMINATION

Only those students who successfully complete the qualifying examination will be admitted to candidacy of the degree. The qualifying examination consists of only Viva-voce examination.

14.1 Minimum requirement for qualifying Viva-voce Examination

The students who have completed all the courses and earned a grade point average of not less than 7.5 will be permitted to appear for the qualifying examination. Students who do not satisfy these requirements shall not be permitted to take up the qualifying examination. The qualifying examination will be conducted after the successful completion of course work.

14.2 Selection of Examiner

A panel of five external examiners for qualifying examinations shall be given by the RAC in consultation with HOD before three months of the date of completion of the student's course work to the Director, DARE. One of them will be appointed as external examiner.

14.3 Qualifying Viva-Voce Examination

14.3.1 The evaluation should cover both the research problem and theoretical background to execute the project. This shall assess the aptitude of the student and suitability of the student for the given research topic.

14.3.2 The RAC shall conduct the qualifying viva-voce examination with one external member, who shall be a specialist in the subject from outside the university.

14.3.3 The Head of the Department will monitor and coordinate the conduct of the qualifying viva. The performance of the candidate will be graded as Satisfactory / Unsatisfactory.

14.4 Communication of Results of Qualifying Examination

The Research Supervisor shall act as chairman for the examination committee and shall be responsible for communicating the results of the examination to the Director, DARE through HOD in the prescribed format.

14.5 **Failure /Absence in Qualifying Examination**

14.5.1 When a student fails or absents for the qualifying examination, he/she may apply again for permission to appear for re-examination to the Director, DARE with the recommendation of the RAC and Head of the Department.

14.5.2 A student, who applies for re-examination should attend viva-voce. Re-examination shall not take place earlier than one month after the first examination. It will be conducted by the RAC as previously indicated.

14.5.3 If a student fails in the re-examination, further re-examination will be considered on the recommendation of the RAC, HoD and Dean, Faculty of Agriculture. If the student fails in the qualifying examination, he/she is not permitted to register for further research credits in the next semester.

15. THESIS RESEARCH

15.1 **Selection of Topic**

15.1.1 The thesis research for the Ph.D. degree should be of the nature of a definite contribution to the subject and the results should be of sufficient importance to merit publication. The findings should have some practical utility or should lead to theoretical contribution.

15.1.2 The thesis shall be on a topic falling within the field of the major specialization and shall be the result of the student's own work. A certificate to this effect duly endorsed by the major advisor shall accompany the thesis

15.2 Research Proposal

15.2.1 The research scholars shall present their broad area of research and submit a proposal to the Research Advisory Committee at the end of the first semester.

15.2.2 The research proposal has to be presented by the student in a meeting organized by the Head of the Department to get the opinion / suggestion of the faculties of the Department for improving it. Three copies of the research proposal in the prescribed format should be sent to the Director (DARE) through the Head of the Department for approval.

15.2.3 The distribution of research credit will be as follows:

Semester	Credit Hours
I Semester	0+2
II Semester	0+10
III Semester	0+16
IV Semester	0+16
V Semester	0+16
VI Semester	0+15
Total	**0+75**

15.3 **Evaluation of Thesis Research**

15.3.1 After assigning the research problem, for each semester, the student has to submit a detailed programme of work to be carried out by him/her during the semester in the prescribed proforma. After scrutiny and approval, a copy of the research programme has to be given to the student for carrying out the work during that semester.

15.3.2 Attendance register must be maintained in the department by HOD for all the students to monitor whether the student has 80% of attendance in research.

15.3.3 The student has to submit his/her research observation note book to the Research Supervisor, who will scrutinize the progress and sign the note book with remarks as frequently as possible. This note book will form the basis for evaluation of research progress.

15.3.4 After completion of 80% attendance for research and on or before the last day of the semester, the research scholars, shall submit Progress Reports in the prescribed format duly endorsed by the Research Advisory Committee to the Director, DARE until they submit their synopsis.

15.3.5 Failure to submit the progress reports shall entail automatic cancellation of registration.

15.3.6 The minutes of the meeting of the Research Advisory Committee along with enclosures will be sent to the Director, DARE.

15.3.7 Candidates who are recipients of fellowships such as JRF/SRF directly from any of the funding agencies/ shall send the progress reports and the utilization certificates in the format prescribed by the respective funding agency through proper channel.

15.3.8 The procedure of evaluating research credits under different situations are explained hereunder.

SITUATION – I

The student has completed the research credits as per the approved programme and awarded **SATISFACTORY** by the RAC. Under the said situation, the student can be

permitted to register for fresh research credits in the subsequent semester. If the student is awarded **UNSATISFACTORY**, he/she has to re-register the same block of research credits in the subsequent semester.

SITUATION – II

The student who has not secured the minimum attendance of 80 per cent shall be awarded grade 'E'. The student has to re-register the same block of research credits for which 'E' grade was awarded earlier in the following semester with prior permission. Until the completion of re-registered credits, the student should not be allowed to register for fresh (first time) research credits.

SITUATION – III

The student could not complete the research as per the approved programme of work for reasons beyond his/her control such as,

- Failure of crop
- Non-incidence of pests or disease or lack of such necessary experimental conditions.
- Non-availability of treatment materials like planting materials chemicals, etc.
- Any other impeding / unfavorable situation for satisfying the advisory committee.
- Under the said situations, grade **EE** should be awarded.

In the mark list, it should be mentioned that E grade or EE grade was awarded due to 'lack of attendance' or 'want for favourable experimental conditions'.

SITUATION – IV

When the student fails to complete the work even in the 'second time' registration, the student will be awarded **UNSATISFACTORY** and, in the mark, list the 'second time' should be mentioned.

For the registration of research credits for the third time, permission has to be obtained from the Dean based on the recommendation of the RAC, and HOD.

Permission for registration for the fourth time shall be given only by the University based on the recommendation of the RAC, HOD and Dean, Faculty of Agriculture.

16. SUBMISSION OF THESIS

16.1 The research credits registered in the last semester should be evaluated only at the time of the submission of thesis, by the RAC. Students can submit the thesis at the end of the final semester.

16.2 If a student has completed the thesis before the closure of the final semester, the research supervisor can convene the RAC meeting and take decision on the submission of the thesis, provided the student satisfies 80 per cent attendance requirement.

16.3 The candidate shall be allowed to submit his/her thesis after the completion of stipulated period. A grace period of 30 days may be allowed to submit the thesis after the prescribed duration. If the thesis is not submitted even after the grace period, the student shall pay the tuition fee for the ensuing year.

16.4 If a student is not able to submit the thesis within the grace period, the student has to re-register for the credits in the forthcoming semester. The student who re-registers the credits after availing of the grace period will not be permitted to avail of grace period for the second time. The Head of the Department can sanction the grace period based on the recommendation of advisory committee and a copy of the permission letter along with the receipt for payment of fine should accompany the thesis while submission.

16.5 Three copies of the thesis (in the approved format) shall be submitted together with the submission fee not later than three months after the submission of the synopsis.

16.6 No dues certificates from the Department and Central Libraries, Hostel, Stores, etc. must be submitted with the thesis copies. The Research Supervisor shall forward the thesis copies with the enclosures to the Director, DARE through the HOD and the Dean. A soft copy of the thesis in PDF format as prescribed by Shodhganga, shall also be submitted.

16.7 The Ph.D. scholars have to publish a minimum of two research papers in NAAS rated journals with 5 and above rating/ Scopus / Web of Science indexed journals at the time of publication of the papers. The synopsis will be accepted for processing only after showing evidences for publications of two such research papers.

16.8 The soft copy of the thesis shall be checked for plagiarism using Turnitin software. Beyond the percentage of reproduction prescribed by UGC, the thesis will not be accepted for valuation.

16.9 **Pre-submission Presentation**

16.9.1 The pre-submission presentation of the thesis is a requirement to enrich the scholar and to fine tune his/her research presentation. This presentation shall be conducted before the submission of the synopsis in the presence of the RAC, Supervisor/Co-Supervisor, HoD, Faculty members, Research Scholars and/or P.G. Students.

16.9.2 The scholar shall present the findings. The gathering may suggest ideas / references to be consulted / suggestions to improve the work.

16.9.3 A report on this event along with an attendance sheet shall be forwarded by the Research Supervisor with the endorsement of the RAC and HOD to the Director, DARE.

16.10 Submission of Synopsis

16.10.1 The submission of synopsis may be permitted 3 months before the completion of required duration on successful completion of course work.

16.10.2 The Research Scholar shall submit 3 copies of the synopsis approved by the Research Advisory Committee along with a soft copy to the Director, DARE through the Research Supervisor, the HOD and Dean of the respective Faculty.

16.10.3 Guidelines for the preparation of the synopsis are appended in Appendix I. Name of the candidate and name of the supervisor shall not be mentioned anywhere in

the synopsis; enrolment number of the candidate alone shall be given. A model cover page for a synopsis is given in Appendix III.

16.11 **Guidelines for Preparation of Thesis**

16.11.1 The thesis shall not exceed 250 pages excluding the Bibliography, Appendices, etc. If it exceeds the specified number of pages, the Research Supervisor should write to university with the reasons and get prior approval from the University. The candidate shall pay a penalty for the excess number of pages as decided by the Deans Committee. The thesis should be in A4 size.

16.11.2 The specification for the preparation of the thesis is given in Appendix II. A model cover page for a thesis is given in Appendix IV.

16.11.3 The thesis shall be typed on both sides of the page in order to save paper and postage. The thesis shall contain a Certificate from the guide (Annexure) specifying that the thesis submitted is a record of research work done by the candidate during the period of study under him/her and that the thesis has not previously formed the basis for the award of any Degree, Diploma, Associate ship, Fellowship or similar title.

16.11.4 A statement from the guide indicating the extent to which the thesis represents independent work on the part of the candidate should also be made. (Appendix V)

16. VALUATION OF THE THESIS

17.1 **Panel of Examiners**

17.1.1 The thesis submitted in partial fulfilment of the Ph.D. degree shall be evaluated by two external experts one from within the country and the other from outside the country appointed by the Vice-Chancellor on the recommendation of the Research Supervisor of the RAC, HOD and Dean.

17.1.2 The external experts shall be chosen from a panel of at least five names of specialists separately from within the country and outside the country in the particular field, suggested by the Research Supervisor.

17.1.3 The external experts shall send their evaluation reports on the thesis directly to the Director, DARE along with the copy of the evaluated thesis. The Director, DARE on receipt of the reports from the two examiners will send them to the concerned Research Supervisor who is the convener of viva-voce board.

17.1.4 The Research Supervisor will send the consolidated report with his remarks to the Director, DARE through the Head of the Department. Based on the satisfactory reports of the evaluation, Viva-voce examination will be arranged.

17.1.5 After a student's thesis for Ph.D. degree is evaluated as indicated above, the thesis shall be finally accepted for the award only after the student satisfactorily completes the final Viva-voce examination.

17.1.6 The Viva-Voce board comprises the student's RAC with the addition of the external examiner who valued the thesis, and the HOD. If the HOD happens to be the Research Supervisor, the Dean, Faculty of Agriculture will nominate a senior member of the staff of the concerned Department as a member.

17.1.7 The candidate is expected to defend the thesis at the Viva-voce examination. The degree shall be awarded on the unanimous recommendation of the Viva-Voce board as

satisfactory with regard to the thesis and the performance of the student in the final Viva-voce examination.

17.1.8 The recommendation of the Viva-Voce board shall be forwarded to the Director, DARE by the Research Supervisor through HOD and Dean which shall be signed by all members of the committee and the external examiner.

17.1.9 A candidate who is not successful (unsatisfactory) at the Viva–voce examination will be permitted to undergo the Viva-voce examination again within a period of three months

17.2 **Revision and Resubmission of Thesis**

17.2.1 If an examiner recommends change / further work, the thesis will be referred to the same examiner after compliance for his/her opinion. In case of rejection by any one of the examiners, the thesis will be sent to another examiner and his / her recommendation will be final.

17.2.2 If the thesis is recommended to be revised by one or both examiners, the points of revision will be indicated clearly in the report. The necessary correction should be carried out, and the revised version should be sent to the concerned examiner(s). If the examiner(s) is / are still not satisfied with the revised version, the thesis will be rejected. If the thesis is accepted by the examiners (Evaluation), Viva–Voce examination will be conducted by the viva-voce board.

17.3 **Re-registration and Submission of Thesis**

The minimum of 80% attendance requirement for submitting the thesis after re-registration need not be insisted for those students who have fulfilled the minimum academic and residential requirement of three years.

17.4 **Extension of Time**

17.4.1 Research scholars who do not submit the thesis within the stipulated period should apply for extension of time three months before the completion of three years. Extension of time and the fees to be paid will be considered by the Deans Committee, if the extension is duly recommended by the RAC, Head of the Department, and the Dean of the Faculty, such candidates will be eligible for extension of time for a maximum period of three years.

17.4.2 The scholar will have to enrol as fresh candidates if he/she fails to submit the thesis within the maximum extension period of three years when granted.

17.4.3 If a scholar requires a few more months after the expiry of the maximum extension period of three years for the submission of the thesis as per the evaluation of the RAC, duly recommended by the Head of the Department and the Dean of the Faculty, as an exceptional case, the Deans committee may consider for re-registration to enable the scholar to submit the thesis. In any case, the time granted shall not exceed six / twelve months.

17.5.1 Number of Chances

17.5.1 A candidate will not be permitted to submit a thesis for the degree on more than two occasions. However, it will be open to the Syndicate, if the Board of Examiners so recommend, to permit the candidate to submit a thesis on a third occasion.

17.5.2 Also, he / she will not be permitted to appear for the viva-voce examination on more than two occasions.

18. DISCONTINUANCE AND READMISSION

18.1 Students admitted to the Ph.D. degree who discontinue their studies before completing the degree with written permission from the university may be re-admitted to the degree programme, provided that the student should have completed the course work before such discontinuance. However, the period of such discontinuance should not exceed five years for Ph.D. Degree from date of admission.

18.2 After completion of course work and qualifying examination, a student is eligible to discontinue temporarily his research program only once within 5 years for Ph. D. program. If the discontinuation period exceeds two semesters, the student has to forego the research credits already registered and register afresh with revised program.

18.3 In the case of field experiments or laboratory experiments in which continuity is essential for research and if a student temporarily discontinues in the middle without completing the experiments, then the entire experiment should be repeated, even if the discontinuation period does not exceed two semesters.

18.4 A student joining the studies, after discontinuation should pay the fees of the existing semester.

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ANNAMALAI UNIVERSITY
DEPARTMENT OF MICROBIOLOGY
FACULTY OF AGRICULTURE

S.No	Course code	Course Title	Credit hour (Theory + Practical)
1	AGM 601	Recent development in Soil Microbiology	2(2+0)
2	AGM 602	Improvements in Fermentation Technology	3 (2+1)
3	AGM 603	Microbial Physiology and Regulation	2(2+0)
4	AGM 604	Recent Approaches in Environmental Microbiology	3(2+1)
5	AGM 605	Plant Microbe interactions	2(1+1)
6	AGM 606	Microbial Genetics	2(2+0)
7	AGM 607	Algal Biotechnology	2(2+0)
8	AGM 608	Advances in Microbial Biotechnology	2(2+0)
9	AGM 609	Industrial Microbiology	2(2+0)
10	AGM 610	Food Safety Management	2(2+0)
11	AGM 611	Agricultural Beneficial Micro Organisms	2(2+0)
12	AGM 691	Doctoral Seminar - II	1(0+1)
13	AGM692	Doctoral Seminar - II	1(0+1)
14	AGM 699	Doctoral Research	75(0+75)

ANNAMALAI UNIVERSITY
DEPARTMENT OF MICROBIOLOGY
FACULTY OF AGRICULTURE

PROGRAMME OUTCOMES (PO)

GMIC 81 Ph.D. (Agricultural Microbiology)

PO1 Students will be given latest and advanced information about microbial metabolism pertaining and the mechanism of nutrient transport, physiological functions specialized structures, enzymatic reactions, bioenergetics pathways and regulation of metabolism.

PO 2 - Students will study the genomic pattern of prokaryotes and eukaryotes, molecular basis if mutation and techniques of gene mapping by recombination and complementation, gene cloning and sequencing.

PO 3 - To understand the impact of various types of environmental pollution and their sources and environmental pollution management strategies by following bioremedial measures.

PO 4 - To give an in depth information about soil microbial communities, plant microbe interactions pertaining to signal transduction, gene expression, specific regulators, biogeochemical cycles and microbial degradation of pesticides and organic wastes.

PO 5 - To understand the principles and methods of food preservation, use of microbial enzymes in food industries and significance of fermented foods and dairy products.

PO 6 - To impart a thorough knowledge in the concepts and types of biofertilizers, biopesticides, mass production technologies and their quality control.

PO 7 - To study and understand the industrial application of microorganisms, design of fermentors, use of genetically modified microorganisms in biotechnology

AGM 601 –RECENT DEVELOPMENT IN SOIL MICROBIOLOGY (2+0)

Learning Objectives:

- To impart knowledge on soil molecular ecology and its role in soil fertility
- Students will understand the root soil interface and microbial interaction
- Students will have knowledge on the importance of microbial inoculants
- Students will learn about microbial transformation of organic compounds.
- To gain knowledge on the role of microbes in bioremediation.

Theory

UNIT I- Molecular Ecology

Soil biota and molecular ecology, heterogenity of organisms in different soils; Role of Microorganisms in soil ferlity - environmental factors affecting on microbes- biotic and abiotic- Genetic and biochemical markers to investigate microbial community.

UNIT II-Root Soil interface interaction

Rhizobium legume symbiosis- root-soil interface; Microbiology and biochemistry of Nitrogen Fixation - Rhizosphere- phyllosphere organisms- soil enzyme activities and their importance. Microbial interactions.

UNIT III- Microbial inoculants

Microbial inoculants-its role in sustainable crop production -Bacterial inoculants and mass production methods. Fungal inoculants and mass production methods-importance of algal inoculants-developments in different formulations.

UNIT IV- Microbial Transformation

Biogeochemical Cycles - Carbon cycle-Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials.

UNIT V- Biodegradation and Bioremediation

Biodegradation of pesticides, pollutants-Cellulose, hemicellulose and lignin degradation by microbes -Organic wastes and their use for production of biogas and manures. Impact of pollutants in soil-Heavy metal detoxification-Reed bed system.

Current stream of thoughts

Theory Lecture Schedule

1. Soil biota and molecular ecology
2. Heterogenity of organisms in different soils
3. Role of Microorganisms in soil ferlity
4. Environnemental factors affecting on microbes- biotic
5. Environnemental factors affecting on microbes- abiotic
6. Genetic markers to investigate microbial community
7. Biochemical markers to investigate microbial community
8. Rhizobium legume symbiosis
9. **First test.**
10. Root-soil interface
11. Microbiology and biochemistry of Nitrogen Fixation
12. Rhizosphere and its importance to crop plants
13. Phyllosphere and its importance
14. Microbial positive interactions
15. Microbial negative interactions
16. Soil enzyme activities and their importance
17. **Mid semester exam**
18. Microbial inoculants-its role in sustainable crop production
19. Bacterial inoculants and mass production methods
20. Fungal inoculants and mass production methods
21. Importance of algal inoculants
22. Developments in different formulations
23. Carbon cycle
24. Microbial transformations of nitrogen
25. Microbial transformations of phosphorus
26. Microbial transformations of sulfur, iron and manganese
27. Siderophores and antimicrobials
28. Biodegradation of pesticides

29. Biodegradation of, pollutants
30. Cellulose, hemicellulose and lignin degradation by microbes
31. Organic wastes and their use for production of biogas and manures
32. Impact of pollutants in soil
33. Heavy metal detoxification
34. Reed bed system

Course outcomes

CO-1: To understand the soil microbial biomass, its role in soil fertility and molecular diversity of microbes.

CO-2: The students acquire knowledge in soil microbial interactions and nitrogen fixation.

CO-3: The student's understand on the various microbial inoculants and its role in sustainable crop production.

CO-4: Students will gain knowledge on the importance of biogeochemical cycle.

CO-5: Students will get through knowledge on the role of microbes in bioremediation.

CO –PO MAPPING MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	-	-	-	3	-	-	-
CO 2	-	-	-	3	-	-	-
CO 3	-	-	-	-	-	3	3
CO 4	-	-	-	3	-	-	-
CO 5	-	-	3	3	-	-	3

Reference Books

1. Coyne.M.S.2000.Soil microbiology.BS Publications, New Delhi.
2. Dixin,G.R.,2010.Soil Microbiology and sustainable crop production. Springer Publisher.
3. Martin Alexander.1977. Introduction to soil Microbiology. John Wiley Publication. New Delhi.

4. Rangaswamy.G and Bagyaraj.D.J.1992.Agricultural Microbiology, Asia Publishing House, New Delhi.
5. Subha Rao, N.S 1999 soil Microorganisms and plant growth. oxford and IBH. New Delhi.

E reference

1. www.nature.com
2. www.microbiologysociety.org
3. http://www.microbeworld.org
4. http://www.armscience.org
5. http;//www.asm.org

AGM 602- IMPROVEMENTS IN FERMENTATION TECHNOLOGY (2+1)

Learning objectives:

- To exposes into latest in biochemical techniques with industrial practises.
- To development and improvement of existing manufacturing system (or) design new ones.
- To know about the basics of bioprocess engineering and fermentor design.
- To improve the strategies to obtain higher yields and production.
- To know the latest development in fermentation industries.

THEORY

UNIT-1 Fermentation

Fermentation- History, Current status and Scope and its importance, Fermentation types- Batch, Continuous and fed batch culture- Upstream process and Downstream process.

UNIT-2 Fermentors

Fermentor- Design- Types- Airlift fermentor- Tower fermentor Fluidized Bed- CSTF- Media for Inoculum fermentation- Criteria for media formulation- Instrumentation and control in fermentors- Biosensors and Computer applications.

UNIT-3 Fermentation process

Screening- Primary and Secondary screening for industrial microorganisms- New strategies for isolation of industrially important microbes- Selection and Strain improvement for brewing and Antibiotics.

UNIT- 4 Industrial Fermentation Production

Production of Lactic acid, Acetic acid, Citric acid, Ethanol- Antibiotics- Penicillin, Streptomycin, Vitamin- B_{12}, Riboflavin, Amino acid- Lysine, Glutamic acid, Beverages- Beer, wine.

UNIT- 5 Microbial Transformation

Microbial colourant- Value addition through microbial fermentation- Strain improvement Biofertilizers and Biopesticides production- Industrial wastes

production - Treatment of biological wastes- Effluent treatment process- **Current stream of thoughts**.

LECTURE SCHEDULE

1. History, Current status and scope, Importance of fermentation.
2. Fermentation types- Batch, Continuous and Fed batch.
3. Upstream process.
4. Downstream process.
5. Downstream process.
6. Fermentor design.
7. Types of fermentor- Airlift fermentor, Tower fermentor.
8. CSTF fermentor and Fluidized bed fermentor.
9. **First test.**
10. Media for Inoculum fermentation and Criteria for media formulation.
11. Instrumentation and control in formulation.
12. Biosensors and computer applications.
13. Screening- Primary screening for Industrial microbes.
14. Secondary screening for Industrial microbes.
15. New strategies for isolation of industrial important microbes.
16. Selection and Strain improvement for brewing and Antibiotics.
17. **Mid Semester Exam**.
18. Production of Lactic acid, Acetic acid.
19. Production of Citric acid and Ethanol.
20. Production of Antibiotics- Penicillin and Streptomycin.
21. Production of vitamins-$B_{12}$and Riboflavin.
22. Production of Aminoacid- Lysine, Glutamic acid.
23. Production of Beverages- Beer and Wine.
24. Microbial transformation- Microbial colourant.
25. Value addition of Microbial fermentation.
26. Strain improvement of Biofertilizers production.
27. Strain improvement of Biopesticides production.
28. Types of industrial wastes and characteristics.
29. Treatment wastes by Physical and Chemical methods.
30. Treatment of biological wastes- microbes of enzymes.
31. Effluent treatment process- Primary treatment.
32. Effluent treatment process- Secondary treatment.
33. Effluent treatment process- Tertiary Treatment.

34. Visit to fermentation Industry.

PRACTICAL SCHEDULE

1. Isolation and screening of industrially important microbes from different samples.
2. Strain improvement by mutagenesis.
3. Assessing the improved strains for maximum efficiency.
4. Work experience on fermentor designs and their different parts-running a lab scale fermentor.
5. Designing the production medium.
6. Optimization of fermentor parameters in commercial production.
7. Production of alcohol on large scale production under continuous fermentation.
8. Production of wine.
9. Production of antibiotic in a lab scale fermentor and testing the efficiency.
10. Production of cellulase enzyme by solid state fermentation.
11. Pigment (Organic colorant) production by solid state fermentation.
12. Determination of enzyme activity from commercially available samples.
13. Downstream process for cell separation.
14. Downstream process for metabolite purification.
15. Treatment of industrial effluents by microbes.
16. Visit to fermentation industry.
17. **Final practical examination.**

COURSE OUTCOME

CO1-Describe current knowledge in biological and biochemical technology.

CO2-Asses the process of bioreactors and new concept of the Fermentation Technology.

CO3-Analyse the bioprocess-Upstream process and Downstream process.

CO4-Examination of various Industrial Production process.

CO5-Examination of Industrial waste water.

CO-PO MAPPING MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	1	3	-	-	-
CO2	-	-	2	3	-
CO3	-	-	3	-	3
CO4	-	1	-	3	-
CO5	-	-	3	-	-

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2. Cruger, Wand A. Cruger. 2004. Biotechnology- A Textbook of Industrial Microbiology.2nd Ed. Panima Press, USA.
3. EL-Mansi, E.M.Y and C.F.A Bryce. 2004.Fermentation Microbiology and Biotechnology. Taylor and Francis, London.
4. Reed, G. 1987. Prescott and Dunn's Industrial Microbiology.4th Ed. CBS, New York.
5. Stanbury, P.F., A. Whitaker and J. Hall. 2016. Principles of Fermentation Technology 3rd edition. Butterworth. Heinemann.

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2. http://www.chalmers.se/en/areas-of-advance/lifescience/research/Pages/Fermentation-Technology.aspx.
3. https://www.longdom.org/fermentation-technology/current-issue.html.
4. http://www.microbiology online.org.UK
5. https://www.coursera.org/lecture/industrial-biotech/microbial-fermentation-processes-and -bioreactor-design-35cbb.

AGM 603 MICROBIAL PHYSIOLOGY AND REGULATION (2+0)

Learning objectives:

- To acquaint students with current topics in molecular microbiology.
- Course imparts thorough knowledge about the synthesis of biomolecules in microorganisms by various pathways and their regulation
- To impart knowledge on microbial physiology, different regulatory pathways and their regulation in bacteria, archaea and viruses
- The students will study how bio energetic can drive (or) limit the metabolic activity.
- Students will able to develop an awareness of the impact interpret how microbial populations can be manipulated to perform specific process.

THEORY

Unit I: Molecular Aspects of Various Cell Component

Origin, evolution, structure, function and molecular aspects of various cell components. Differentiation in bacteria, slime molds, yeasts. Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria

Unit II: Regulatory Pathways in Bacteria-I

Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor. Regulatory controls in bacteria - inducible and biosynthetic pathways. Gene control of quorum sensing. Oxidative stress control and stringent control. Fermentative and respiratory regulatory pathways.

Unit III: Regulatory Control in Bacteria-II

Ribosomal RNA and ribosomal proteins- Regulation under stress conditions. Specific regulatory systems; SOS regulatory control; RNA based regulation – sRNA, riboswitches, attenuation and antisense RNA regulation of gene expression. Biosynthesis of micromolecules (Nucleotides and Amino acids) macromolecules (DNA, RNA, Proteins) Global nitrogen control and regulation of nitrogen fixation (nif regulon) and phosphate uptake (phosphate (Pho) regulon). Regulation of biosynthetic pathways in bacteria capable of degrading recalcitrant substances.

Unit IV: Regulatory Control in Archaea

Extremophiles - thermal stress and heat shock response; pH stress and acid tolerance. Transcriptional control in archaea- DNA binding protein, sensing and signal transduction and global control

Unit V: Regulatory Control in Bacteriophages

General characteristics of bacteriophages. Regulation of lytic and lysogenic cascade in phage bacteria interactions-

Current stream of thoughts.

LECTURE SCHEDULE

1. Molecular logic of life – prebiotic evolution. Chemical unity of diverse living organisms
2. Evolutionary relationship among microorganisms – evolution and structure of prokaryotic and eukaryotic cells.
3. Evolution of multicellular organisms and cellular differentiation
4. Functions of various cell organelles
5. Differentiation in bacteria, slime molds, yeasts
6. Bioluminescence – principles and mechanism and molecular aspects of bioluminescence
7. Bacterial virulence –vir proteins. Biological effects of various vir proteins in bacterial pathogens
8. Heat shock response. Extracellular protein secretary system, Regulation of initiation and termination of transcription in bacteria
9. **First test**
10. Regulation of anti-termination of transcription in bacteria
11. Sensing and signal transduction – chemo taxis and gene control of quorum sensing
12. Global regulation and differentiation by sigma factor
13. Regulatory controls of inducible and biosynthetic pathways
14. Regulatory controls of inducible and biosynthetic pathways
15. Oxidative stress control and stringent control
16. Fermentative and respiratory regulatory pathways.
17. **Mid semester Examination**
18. Fermentative regulatory pathways in the synthesis of secondary metabolites
19. Regulation of ribosomal RNA and ribosomal proteins
20. Specific regulatory systems and SOS regulatory control
21. Regulation of chromosomal repair mechanisms in bacteria
22. RNA based regulation – sRNA, riboswitches, attenuation and anti-sense RNA regulation of gene expression

23. Biosynthesis and regulation of micromolecules (Nucleotides and Amino acids)
24. Biosynthesis and regulation of macromolecules - DNA and RNA
25. Biosynthesis and regulation of macromolecules Proteins
26. Regulation of fatty acids and lipid bio synthesis
27. Regulation of nitrogen fixation and phosphorous regulons
28. Regulation of biosynthetic pathways in bacteria capable of degrading recalcitrant substances
29. Regulation of enzymes and other proteins – feedback inhibition and post translational regulation and proteolytic control
30. Extremophiles-thermal stress and heat shock responses; pH stress and acid tolerance.
31. Transcriptional control in archaea
32. Translational control in archaea
33. General characteristics of bacteriophages
34. Regulation of lytic and lysogenic cascade in phage bacteria interactions.

COURSE OUTCOME

CO1:Students are expected to understand thoroughly about the synthesis of biomolecules in microorganisms by various pathways and their regulation.

CO2:This course presents major concepts in the physiology of microbes, primarilybacteria and archaea.

CO3: The dynamic nature of microbes as they sense and respond to changingenvironments will be observed.

CO4: Thestudent will have an increased understanding of the techniques used to explore andexploit microbial physiology and the ability to critically assess scientific literature in this field.

CO5: To know the current status of molecular microbial physiology.

CO-PO MAPPING MATRIX

	PO 1	PO2	PO3	PO4	PO5	PO6	PO 7
CO1	3	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-
CO3	2	-	-	-	-	-	-
CO4	3	-	-	-	-	-	1
CO5	3	-	-	-	-	-	2

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2. Lewin, B, 2003. Gene VIII. Pearson Education, New York.
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4. Cossart, P., P. Boquet, S. Normark and R. Rappuoli. 2000. Cellular Microbiology. ASM Press, ISBN 1- 55581-157-4.
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3. https://bmb.psu.edu/undergraduate/courses/course-archive/2016/fall2016/microbiology-micrb/micrb-401-fall-2016/micrb-401-microbial-physiology-andstructure
4. https://www.researchgate.net/journal/0065-2911_Advances_in_Microbial_Physiology
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AGM 604 RECENT APPROACHES IN ENVIRONMENTAL MICROBIOLOGY (2+1)

Learning objective

- To know the fundamental features of microorganisms and their adaptations in various environment.
- To understand their roles in the functioning of our ecosystems and their importance to mankind.
- To impact knowledge in the degradation of the xenobiotic compounds
- To gain the idea about the organisms that are living in the fascinating world of extreme environment and their biotechnological applications.
- To gain the knowledge about the role of microbes in Biodegradation, Biomining and Bioremediation

Theory

Unit I : Microbial Ecology

Microbes in the environment. Microbial evolution and biodiversity – Ecological niches – Definitions, biotic and abiotic environment. Environmental segments. Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Food chains, food webs and trophic structures. Ecological pyramids. Biogeochemical cycling and its consequences. Terrestial and aeromicrobes and their Importance to the life. Biofilms- and microbial mats – Aquatic ecosystems- Public Health Microbiology. Bacteriophages in waterbodies.

Unit II : Extremophiles, Adaptations, and Their Applications

Extremophiles: Definition and ecological aspects. Microbes in air-water interface, High Temperatures and Springs. Thermophiles–Xerophiles- Psychrophiles-Piezophiles - Alkaliphiles. -Acidophiles- Halophiles and Barophiles- Methane and chlorates on Mars; Environmental Distribution and Taxonomic Diversity- Physiology & adaptive mechanisms - Extremozymes –Applications.

Unit III : Microbes and Energy

Microbial metabolic pathways for bioenergy production. Plant and algal biomass resources. Biowastes to wealth. Biocatalysts and their applications. Secondary products. Microbial Fuel cells.Biorefinery. Future fuels and platform chemicals. Climate change affecting microbes; role of microbes in climate change and recycling; micobes in changing world- plant microbe adaptations.

Unit IV : Microbiology of Wastewater and Solid Waste Treatment

Wastes-types-solid and liquid wastes characterization, physical, chemical, biological (aerobic, and anaerobic), primary, secondary and tertiary treatments. Anaerobic processes-Bioremediation of nuclear wastes. Bioconversion of Solid Wastes and utilization as fertilizer.

Unit V : Biodegradation, Biomining and Bioremediation

Process of biodegradation. Microbial community structure and biodegradability. Bioaccumulation of heavy metal ions from industrial effluents-Bioavailability- Biomining. Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behavior. Factors affecting degradation. Organic pollutants- sources and types. Process including aerobic and anaerobic. Bioremediation-Types- Newer and enhanced processes.

Current stream of thoughts

Theory lecture schedule

1. Microbes in the environment and their importance

2. Microbial evolution and biodiversity

3. Ecological niches – Definitions, biotic and abiotic environment

4. Environmental segments. Composition and structure of environment

5. Concept of biosphere, communities and ecosystems, Ecosystem characteristics, structure and function, Food chains, food webs and trophic structures

6. Ecological pyramids. Biogeochemical cycling and its consequences

7. Terrestrial and Aeromicrobes and their Importance to the life

8. Biofilms- and microbial mats, Aquatic ecosystems- Public Health Microbiology

9. **First Test**

10. Bacteriophages in waterbodies

11. Extremophiles- Definition and ecological aspects

12. Microbes in air-water interface, high temperatures and springs

13. Thermophiles –Xerophiles- Psychrophiles-Piezophiles -Alkaliphiles. - Acidophiles

14. Halophiles and Barophiles- Methane and chlorates on Mars

15. Environmental Distribution and Taxonomic Diversity- Physiology & adaptive mechanisms

16. Extremozymes and their applications

17. **Mid semester examination**

18. Microbial metabolic pathways for bioenergy production

19. Plant and algal biomass resources for biofuel production

20. Biowastes to wealth-Sources of lignocellulosic biomass

21. Biocatalysts and their applications. Secondary products

22. Biorefinery. Future fuels and platform chemicals. Microbial Fuel cells

23. Microbial world in a changing world and Role of microbes in climate change and nutrient cycling

24. Microbial world in a changing world and Role of microbes in climate change and nutrient cycling

25. Mitigation of GHGs using microbes

26. Wastes-types-solid and liquid wastes characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments

27. Anaerobic processes-Bioremediation of nuclear wastes

28. Bioconversion of Solid Wastes and utilization as fertilizer

29. Xenobiotics and organic pollutants- Process of biodegradation

30. Microbial community structure and biodegradability

31. Bioaccumulation of heavy metal ions from industrial effluents-Bioavailability- Biomining

32.Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behavior

33. Factors affecting degradation. Organic pollutants- sources and types. Degradation process including aerobic and anaerobic

34. Bioremediation-Types- Newer and enhanced processes

PRACTICAL SCHEDULE

1. Biotrap based selective isolation of functional microbes from contaminated environments

2. Assay and quantification of thermophlic enzyme in biomass deconstructions

3. Demonstration of biodelignification and saccharification using thermophilic enzyme cocktails

4 .Characterization of halophilic microbes from salt lake

5. Isolation of bacteriophages from water bodies

6. Demonstration of pesticide degradation by microbes

7. Determination of indices of pollution by measuring BOD/COD of different effluents

8. Bacterial reduction of nitrate from ground waters

9. Effect of climate change on root microflora

10. GHG mitigation by microbes

11. Microbial composting of crop residues

12. Biomethanization of crop residues

13. Recovery of toxic metal ions of an industrial effluent by immobilized cells

14. Utilization of microbial consortium for the treatment of solid waste (Municipal Solid Wastes)

15. Biotransformation of toxic chromium into non-toxic

16. Microbial dye decolourization/adsorption

17. **Final practical examination**

Course outcomes

CO-1: The student understands the dynamic interaction of the microbes with the physical and chemical makeup of world's many ecosystems.

CO-2: The students acquire the knowledge of preserve the natural environment.

CO-3: The students will gain knowledge on the role of microbes play in maintaining the chemical balance between available nutrients and in metabolizing waste products.

CO-4: The students will get through the knowledge on the role of microbes in solid and liquid waste management.

CO-5: The students will understand the role of microbes in biodegradation, biomining and bioremediation.

CO –PO MAPPING MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	-	-	2	3	-	-	-
CO 2	-	-	-	3	-	-	-
CO 3	-	-	-	-	-	-	3
CO 4	-	-	-	3	-	-	-
CO 5	-	-	3	-	-	-	3

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AGM 605 Plant Microbe Interactions (1+1)

OBJECTIVE

- To make the students understand the various interactions in plant –microbe at molecular level.
- To understand various mechanical changes, pathway modulation and defensive actions in plant metabolism due to such interactions
- Students acquire knowledge about Metabolomics and Proteomics
- Student about Infection mechanisms, defense of plants and stress responses and a large number of important problems within agriculture, horticulture and forestry
- Students with the biochemical and biophysical mechanisms, genetics, genomics, proteomics

Unit I: Scope and Importance Plant Microbe Interactions

Plant MicrobeInteractions for crop health and Productivityroot, rhizosphere, phyllosphere, plant endophytes-Special niches of microbial association. Signal molecules and their regulation in symbiosis and plant health.

Unit II: Signalling and Interactions

Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized. Molecular basis of rhizosphere colonization. Role of plant system in determining the microbial association -Microbial Community dynamics and population interactions employing DGGE, TGGE, T-RFLP.

Unit III: Functional Microbiome

Holobiome-Functional role in soil fertility-supporting plant growth under abiotic stress-drought, salinity. Microbial colonization in plant roots, Plant root border cells production of cell, specific chemo attractants, nod gene inducers, phytoalexins and phosphatases.

Unit IV: Metabolomics and Proteomics in PMI

Metabolite profiling of root exudates-Rhizosphere chemistry. Interaction of root metabolites and root associated microorganism. Microbial elicitors: A positive or negative modulator of plant defense- Plant-Pathogen interactions-PTI and ETI, Downstream events of Plant defense.

Unit V: Transcriptomics in PMI

Gene expression during interaction- Plant and microbial gene expression and signal exchange. Interactions of plant root symbionts and pathogens; nitrogen fixing microorganisms and their interaction (eg.Rhizobium)-Mycorrhizal relationships. Drought and disease responsive gene expression and regulations (eg. Rice).

Theory Lecture Schedule

1 Plant microbiome for crop health and Productivity

2. Microbiome of different plant parts; root, rhizosphere phyllosphere and plant endophytes

3 Microbiome of different plant parts; Special niches of microbial association

4 Signal molecules and their regulation in symbiosis and plant health

5. First test

6.Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized

7. Molecular basis of rhizosphere colonization. EPS & Biofilm formation and their role colonization

8. Role of plant system in determining the microbial association -Microbial Community dynamics and population interactions employing DGGE, TGGE, T-RFLP

9.**Mid semester examination**

10.Holobiome and their importance in crop productivity

11. Functional role of microbiome in abiotic stress management and Microbial colonization in plant roots

12. Plant root border cells production of cell specific chemo attractants, nod gene inducers, phytoalexins and phosphatases

13. Root exudates-diversity of chemical constituents and interaction of root metabolites and root associated microorganism

14 Microbial elicitors: A positive or negative modulator of plant defense

15 Plant-Pathogen interactions - PAMP-mediated resistance and bacterial counterstrategies

16. Transcriptomics-Gene expression during interaction- Plant and microbial gene expression and signal exchange

17. Interactions of plant root symbionts and pathogens; nitrogen fixing microorganisms and their interaction (eg. Rhizobium)-Mycorrhizal relationships

18. Drought and disease responsive gene expression and regulations (eg. Rice)

PRACTICAL SCHEDULE

1 Signal molecules-detection and quantification

2 Metabolites-enrichment, separation and analyses

3 Plant activating proteins-extraction, assay, quantification and bioassay for plant defense priming

4 Soluble metabolites profiling in GC-MS

5 Volatile metabolites profiling in GC-MS/ATD

6 Metabolic pathway analyses

7 Metabolite enrichment analyses

8 Correlation and Network analyses

9 Flow -Cytometry of signal and tagged cells analyses

10 Flow -Cytometry of signal and tagged cells analyses

11 FT-IR based molecular signatures

12 RT-PCR analyses of differential expression of genes

13 RT-PCR analyses of differential expression of genes

14 Differential protein expression by one- and two-dimensional PAGE

15 Metabolites/proteins/biomolecules profiling in LC-MS-MS

16 Effect of signal molecule on nodulation and plant health

17 Final practical examination

Course outcome

CO-1: To understand the molecular interactions between plant- beneficial microbes.

CO-2: Students acquire knowledge Identify the key interacting molecules and characterize their functional attributes

CO-3: To understand the modulation of plant metabolism in response to microbial metabolites for defense priming against biotic and abiotic stress.

CO-4: Students acquire knowledge on exudates-Rhizosphere chemistry, Plant-Pathogen interactions, Antimicrobial metabolites.

CO-5: Students will gain knowledge on Gene expression during interaction, Global and specific regulators for different interactions and Drought and disease responsive gene expression and regulations

CO-PO MAPPING MATRIX

Cos/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	1	-	-	-	-	-
CO 2	2	1	-	-	-	-	-
CO 3	2	1	-	-	-	-	-
CO 4	2	1	-	-	-	-	-
CO 5	1	2	-	-	-	-	-

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AGM – 606 MICROBIAL GENETICS (2 + 0)

LEARNING OBJECTIVES

- To acquire the basic knowledge about the genome of microorganisms.
- To know genetic recombination and mutations that causes variability
- To understand the fungal genetics and its role.
- To know genetic material exchange and transposable elements.
- To develop the skills to work on recent development and technologies on gene sequencing and regulation.

Theory

Unit I: Genome of Microorganisms

Prokaryotic, eukaryotic and viral genome. Replication of eukaryotic, prokaryotic and viral DNA. Structure, classification and replication of plasmids

Unit II : Mutation and Recombination

Molecular basis of mutation. Biochemical genetics and gene mapping by recombination and complementation. Fine gene structure analysis

Unit III : Fungal genetics

Fungal genetics – Genetics of *Neurospora crassa*, *Aspergillus nidulans* and Yeast.

Unit IV : Genetics Material Exchange

Gene transfer in bacteria through transformation, conjugation and transduction; Transposable elements.

Unit V : Gene Sequencing and Regulation

Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Regulation of gene expression. Recent advances in DNA repair and mutagenesis. Genetic basis of cancer and cell death.

Current stream of thoughts:

THEORY LECTURE SCHEDULE

1. Evolution of microbial genetics.

2. Comparison between prokaryotic, eukaryotic and viral genomes.
3. Replication of viral DNA.
4. Replication of prokaryotic DNA.
5. Replication of eukaryotic DNA.
6. Structure, classification and replication of plasmids.
7. Mutation; types and uses.
8. Mutagenic agents, Molecular basis of mutagenesis.
9. **First Test**
10. Concept of biochemical genetics.
11. Gene mapping by recombination and complementation.
12. Fine structure of gene.
13. Brief introduction to fungal genetics.
14. Genetics of *Neurospora crassa*, *Aspergillus nidulans.*
15. Genetics of Yeast.
16. Exchange of genetic characteristics between bacteria.
17. **Mid semester examination**
18. Bacterial recombination and their mechanisms.
19. Cellular competence for transformation.
20. Mechanisms of transformation.
21. Conjugation mechanism.
22. Transduction, types of transduction.
23. Transposons and their classes / types.
24. Detailed mechanism of gene cloning.
25. Modern applications of microbial gene cloning.
26. Gene sequencing technique.
27. Automated gene sequencing.
28. Impact of gene cloning on human welfare.
29. Regulation of gene expression.
30. DNA damage and repair.
31. DNA repair mechanisms (Part 1).
32. DNA repair mechanisms (Part 2).
33. Genetic basis of cancer and cell death.
34. Detection of mutants, Reverse mutation and mutation rates

Course outcome:

CO 1: They will understand about the fundamental of genome. Replication of eukaryotic, prokaryotic and viral DNA. Structure, classification and replication of plasmids**.**

CO 2: They will understand gene Molecular basis of mutation and its types, principles of mutants, mutagens, DNA repairing mechanism. Gene mapping by recombination and complementation. Fine gene structure analysis.

CO 3: Students will gain knowledge on fungal genetics.

CO 4: Students will study about genetic material exchange.

CO 5: Students will study and have practical knowledge on Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Recent development in DNA repair and mutagenesis

CO-PO MAPPING MATRIX

	PO1	PO2	PO3	PO4	PO5
CO1	1	-	1	1	1
CO2	1	1	3	2	2
CO3	3	-	-	1	3
CO4	-	2	2	-	-
CO5	2	2	1	2	1

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AGM 607 -ALGAL BIOTECHNOLOGY (2+0)

Objective

- To teach students about the morphology of Algae
- To learn the culturing techniques of Algae
- To impart knowledge on the role of Algae for mankind
- To study on the ecological aspect of Algae
- To train the student on the mass production of Algae

UNIT I – Morphology of Algae

Introduction to Cyanobacteria and algae. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of Cyanobacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes.

UNIT II – Algal **Culturing techniques**

Algal pigments, storage products, carbon metabolism, photosynthesis. Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

UNIT III-Biotechnology and Utilization of Algae

Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes etc) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology, sustainable aquaculture.

UNIT IV – Ecology of Algae

Ecology of algae- distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism.

UNIT V – Bioremediation and Mass Production of Algae

Algae in pollution - as pollution indicators, eutrophication agents and role in Bioremediation.Cyanobacterial and algal toxins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture – biofertilizers & algalization; soil conditioners; reclamation of problem soils.

Current stream of thoughts

Theory Schedule

1. Introduction to Cyanobacteria and algae. Definition, occurrence and distribution,
2. Thallus structure, reproduction, life cycles,

3. Origin and evolution of Cyanobacteria,
4. Molecular evolution
5. Role of algae in evolution of plants
6. Plants and horizontal transfer of genes.
7. Algal pigments,
8. Storage products,
9. **First test**
10. Photosynthesis,
11. Carbon metabolism,
12. Algal culturing and cultivation. Culture types, culture conditions,
13. Culture vessels, culture media, sterilization, culture methods,
14. Synchronous cultures, photobioreactors,
15. Algal density and growth, seaweed cultivation
16. Cyanobacterial and algal fuels,
17. **Mid semester Examination**
18. Fine chemicals (restriction enzymes etc) and nutraceuticals from algae;
19. UV absorbing pigments Industrial products from macro algae - seaweed biotechnology,
20. Sustainable aquaculture
21. Ecology of algae- distribution in soil and water;
22. Primary colonizers,
23. Carbon sequestration
24. Algal cycling in soil and water.
25. Cellular differentiation
26. Nitrogen fixation
27. Nitrogen metabolism
28. Algae in pollution - as pollution indicators, eutrophication agents and role in Bioremediation.
29. Cyanobacterial and algal toxins, allelopathic interactions,
30. Algae in global warming and environmental sustainability.
31. Cyanobacteria and selected microalgae in agriculture –
32. Algal Biofertilizers
33. Algalization;
34. Reclamation of problem soils by algae

COURCE OUTCOME

CO 1. Students will get familiarize with the structure of Algae

CO 2. Students will gain knowledge of how to culture algal species.

CO 3.Student will understand the importance of Algae for mankind

CO 4. Students will know about ecology of algal species and their distribution

CO 5. Students will train on the bioremediation and mass production techniques of algae

CO-PO MAPPING MATRIX

Cos/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-

CO 3	-	-	-	-	-	-	-
CO 4	-	-	-	**2**	-	-	-
CO 5	-	-	**2**	-	-	-	-

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AGM 608 : ADVANCES IN MICROBIAL BIOTECHNOLOGY (2+0)

OBJECTIVE

- To understand the basic knowledge on Microbial biotechnology.
- To learn the advanced techniques used in microbial biotechnology research.
- To explore the knowledge on biotechnological tools and its application in microbial research.
- Studying their evolutionary process and understanding the advances in technology.
- To introduced emphasis knowledge on biotechnological potential of microbes.

THEORY

Unit I: Microbial Diversity

Domain and Kingdom concepts in classification of microorganisms; Criteria for classification; Classification of Bacteria according to Bergey's manual; Improved method of soil DNA extraction; Molecular methods used in microbial classification; Culture Collection and preservation.

Unit II: Microbial Growth Kinetics and Physiology

Microbial growth - yield constants, continuous kinetics, methods of growth estimation; Nutrition; Fermentative metabolism - isolation, preservation and strain improvement of industrially important microorganisms- traditional and genetic methods.

Unit III: Bioprocessing

Fermentors - Physical and chemical control; types -Batch, Fed batch and continuous fermentation-Solid State Fermentation (SSF) and its importance; Immobilization of enzymes and cells; Fermentation medium; Scale-up principles; Down-stream processing, Product development regulation and safety.

Unit IV : Microbial Biotechnology Products -1

Recombinant and synthetic vaccines and its recent advances; Microbial insecticides- Bt- toxin; Microbial polysaccharides**;** primary metabolites- organic acids, amino acid production; secondary metabolites- commercial antibiotic production and its physiology, microbial enzyme production.

Unit V : Microbial Biotechnology Products - II

Biofuel - development and its recent advances; food and beverages fermentation-traditional foods and recent advancements; food additives and supplements; microbial biomass production - SCP; environmental biotechnology - recent technology in waste water treatment and composting; biodegradation - its genetic aspects - Xenobiotics.

Current stream of thoughts

THEORY LECTURE SCHEDULE

1. Importance of the Identification and Classification of Microorganisms
2. Taxonomic Diversity of Bacteria
3. Characteristics of fungi and its classification
4. Classification of Bacteria according to Bergey's manual
5. Molecular methods used in microbial classification - improvement in soil DNA extraction
6. Microbial culture Preservation & Culture collection
7. Microbial Nutrition - Nutritional categories of microorganisms
8. Microbial growth kinetics - batch growth - continuous growth
9. **First test**
10. Determination of growth of microbes - environmental influence on growth
11. Isolation, screening of industrially important microorganisms
12. Strain improvement of industrially important microorganisms
13. Fermentation system - fermentor design and construction
14. Fermentors/ bioreactors - types and classification
15. Fermentation medium formulation
16. Principles and methods used **for** sterilization in fermentor
17. **Mid Semester Examination**
18. Downstream processing - an overview

19. Large scale cell separation techniques and disruption
20. Immobilization of cells and enzymes
21. Vaccines - recombinant and synthetic vaccines
22. Microbial Insecticide - Bt toxins
23. Microbial polysaccharides and its production
24. Microbial primary metabolites - Organic acid production
25. Microbial primary metabolites - Amino acid production
26. Commercial production of antibiotics
27. Commercial microbial enzymes production
28. Biofuels - development and recent advances
29. Fermentation of traditional food products and dairy products
30. Microbial production of food additives and supplements
31. Microbial biomass production - SCP - different methods of SCP
32. Waste water and effluent treatment
33. Composting and its important organisms
34. Biodegradation of xenobiotics.

Course Outcome

CO1 At the end of the course students will understand the basic knowledge of microbial biotechnology.

CO2 This course will also will help the students to know the advanced molecular techniques which can be further used in their microbial research.

CO3 Students will be knowing the genetically improvement of industrially Important microbial strains.

CO4 To gain knowledge of microbial insecticide ;primary and secondary Metabolites.

CO5 Students will be knowing microbial biomass production;Recent Technology in waste water treatment and composting;Bio-degradation.

CO/PO MAPPING

CO/PO	PO_1	PO_2	PO_3	PO_4	PO_5	PO_6	PO_7
CO_1	3	3	-	-	-	-	1
CO_2	2	3	-	-	-	-	1
CO_3	2	1	-	-	-	-	2
CO_4	2	-	-	-	-	2	1
CO_5	2	-	2	-	-	1	1

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AGM 609 - INDUSTRIAL MICROBIOLOGY (2+0)

Learning objectives

- To make the students to understand the role of microorganism in various industries
- To impart knowledge on the preservation technologies
- To impart knowledge on production of different types of Antibiotics, food, dairy products and food safety measures.
- To make the students to know the various spoilage and food borne infection and disease caused by microbes
- To have knowledge on the fermentation technologies of producing value-added foods by microbes

THEORY

Unit- I- Introduction of fermentation

History of industrial microbiology – Isolation and screening methods – strain development strategies – fermentation media – raw materials used in media production and antifoam agents - fermentation process - dual and multiple fermentation process - batch and continuous fermentation, solid state, and submerged fermentation.

Unit-II- Bioreactors and its types

Bioreactors – basic functions - types, designs, and functional characteristics- upstream and downstream processing – automation of bioreactors; Fermenter – basis and operations **with CSTR- types of important fermenters**

Unit -III- Production of organic solvents, organic acids, amino acids and Beverages

Production of organic solvents such as ethyl alcohol and glycerol. organic acids production – butyric acid, citric acid and lactic acid. Amino acid production – lysine and glutamic acid. Beverage's production – beer and wine. – Alcohol production

Unit- IV- Production of Antibiotics, Vitamin and Enzymes

Industrial production of antibiotics – penicillin, streptomycin, and tetracycline production of vitamin B2 (Riboflavin), vitamin B12 and vitamin C. production of enzymes – amylase, protease, cellulase, pectinase and lipase immobilization and its type. Biomining: recovery of minerals from low-grade ores. **Bioplastics and biopolymers-microorganisms involved in synthesis of biodegradable plastics. Microbial pigments (organic colourants).**

Unit- V- Fermented food products, biofertilizers and biopesticides production techniques

Milk and dairy product production – yoghurt, buttermilk, cultured milk and cheese - single cell protein, recombinant proteins. Spirulina, mushroom, probiotic products **- Mechanisms of pesticide degradation by microbes. Xenobiotic compounds and bioremediation. Biosensors-Microbial biosensor and its applications Microbes for enhanced pesticide degradation.**

Current Stream of thoughts

THEORY LECTURE SCHEDULE

1. History of industrial microbiology
2. Screening methods
3. Strain improvement of microorganisms
4. Methods of strain improvement
5. Fermentation media and their raw materials
6. Fermentation process of its Types
7. Bioreactors, design and functional characteristics
8. Types of bioreactors and Upstreaming Processing
9. **First Test**
10. Downstream processing- introduction
11. Details of down steam processing
12. Fermenter and operation-CSTR
13. Production of organic solvents –ethyl alcohol and glycerol
14. Production of organic acid – Butyric, citric and Latic acid
15. Production of Amino acid - Lysine and glutamic acid
16. Production of Beverages - Beer and wine alcohol production
17. **Mid semester Examination**
18. Production of penicillin , streptomycin and tetracycline
19. Production of amylase and protease
20. Production of pectinase, cellulose
21. Production of Lipase
22. Immobilization and its types
23. Biomining: recovery of minerals from low-grade ores**.**
24. Milk product – Butter milk and culture milk
25. Yoghurt production
26. Cheese production
27. Single cell proteins and recombinant proteins.
28. Spirulina, mushroom, probiotic products.
29. Bacterial bio fertilizer production – Azospirillum, Rhizobium and Phosphobacteria
30. Quality control and method of application
31. Mechanisms of pesticide degradation by microbes.
32. Xenobiotic compounds and bioremediation.

33. Biosensors-Microbial biosensor and its applications
34. Microbes for enhanced pesticide degradation.

Course outcome:

CO 1 - To learn about the important industrial microbes and their products.

CO 2 - To learn about the strategies to improve the strain efficiency and preservation techniques for future purposes.

CO 3 -To make the students to understand the concepts and types of fermentation process, types of fermenters, their design and purposes.

CO 4 - To gain knowledge on the techniques of industrial production of organic acids, antibiotics, enzymes, and fermented foods.

CO 5 - To train the students to develop skills on the techniques of mass production of biofertilizers and bio pesticides

CO – PO MAPPING MATRIX

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	2	-	3	-	-
CO 2	-	2	3	-	-
CO 3	-	-	3	-	-
CO 4	-	-	3	-	-
CO 5	-	-	3	-	3

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AGM 610 Food Safety Management(2+0)

OBJECTIVE

- To make the students understand various measures to be under taken to prevent spoilage and to process the foods to perfect value chain.
- To enlighten the students with food safety regulations.
- To provide an understanding of GMPs for processed foods
- To learn the latest trends in food and their impact on human health
- To acquire the knowledge on advanced technique on food safety performance analysis

THEORY

Unit I: Current Issues in Food Safety

Microbial Food Hazards- Significance of foodborne diseases - bacterial and non-bacterial agents of food borne illness- characteristic features of the organisms and the associated foods–Toxins in Food and their impact on human health. Emerging food Safety Issues and the Microbiology of Specific Commodities - Detection Prevention and Control Strategies - Current and Future Issues in Food Safety

Unit II: Hygiene Principles in Food Safety

Hygiene - Personnel, process and industrial hygiene on the safety of the fresh and processed produce. Sanitation - Cleaning compounds, clean-in-place, clean-out-of-place- sanitizers and their characteristics, and GMPs for processed foods.

Unit III: Guide Lines for Quality Control

Pre requisite programmes for Food safety- GAPs- Key Points of Control and Management of Microbial Food Safety for Growers, Packers, and Handlers of Fresh-Consumed Agricultural and Horticultural Products. Good Manufacturing Practices – guidelines and Key Points of Control in processing of foods

Unit IV: Food Safety Performance Indicators / Plans

Pre requisite programs (PRP)- Certified Food Safety Plans - HACCP, GFSI, BRC, SQF, FSSC 22000IFS, Global GAP, ISO 22000, BRC/IOP- Packaging and its importance in food safety for export of agricultural produce- Food standards and specifications.

Unit V: Food Safety Laws

Food Safety Laws and Regulations on Food safety management system –PFA, FPO, MMPO, Agmark, BIS, Codex, FSSAI and their importance. Food safety performance indicators - Safety performance analysis techniques.

Current stream of thoughts

THEORY LECTURE SCHEDULE

1. Definition of Microbial Food Hazards - Significance of foodborne diseases
2. Bacterial and non-bacterial agents of food borne illness.
3. Non-bacterial agents of food borne illness
4. Characteristic features of the organisms and the associated foods
5. Toxins in Food and their impact on human health
6. Emerging food Safety Issues and the Microbiology of Specific Commodities
7. Detection, Prevention and Control Strategies of food borne pathogens
8. Current and Future Issues in Food Safety
9. **First test**
10. Hygiene - Personnel, process and industrial hygiene on the safety of the fresh and processed product
11. Sanitation - Cleaning compounds, clean in place, Cleanout-of-place- sanitizers and theircharacteristics.
12. Quantification of Hygiene Indicator Organisms fresh and processed foods
13. GMPs for processed foods
14. Pre-requisite programmes for Food safety – GAPs
15. Studies on the impact of food plant sanitation on Safety
16. Key Points of Control and Management of Microbial Food Safety for Growers, Packers.
17. **Mid semester examination**
18. Microbial Food Safety for Handlers of Fresh-Consumed Agricultural and Horticultural Products
19. Good Manufacturing Practices – guidelines and Key Points of Control in processing of foods
20. Pre requisite programs (PRP)- Certified Food Safety Plans - HACCP, GFSI, BRC, SQFPackaging and its importance in food safety forexport of agricultural produces
21. FSSC22000 IFS, Global GAP,Packaging and its importance in food safety forexport of agricultural produces

22. ISO 22000, BRC/IOP- Packaging and its importance in food safety forexport of agricultural produces
23. Application of HACCP in Food Industries
24. Food standards and specifications.
25. Food Safety Laws and Regulations on Food safetymanagement system.
26. Codex, FSSAI and their importance.
27. PFA, FPO and their importance
28. MMPO, Agmark, BISand their importance
29. Food safety performanceindicators -Safety performance analysis techniques
30. GAPs- Key Points of Control and Management of Microbial Food Safety for growers
31. Packers, and Handlers of Fresh-Consumed Agricultural and Horticultural Products
32. Good Manufacturing Practices – guidelines and Key Points of Control in processing of foods
33. Safety performance analysis techniques
34. Studies on implementation of TQM-predictive models in microbiology

COURCE OUTCOME

CO 1. At the end of the course, the student would have clear understanding of significance of foodborne diseases to prevent food hazards.

CO 2. Students get trained in sampling plans and microbiological criteria in food and analysis on Interpretation of the results.

CO 3.This course will provide knowledge about guidelines of quality control of foods.

CO 4. Students acquired knowledge about hygiene principles in food safety.

CO 5. The course will also help students to know about food safety laws and regulations to maintain food standards in processing industries

CO-PO MAPPING MATRIX

Cos/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	-		-	-	2	-	-
CO 2	-		-	-	1	-	-

CO 3	**-**		**-**	**-**	**1**	**-**	**-**
CO 4	**-**		**-**	**-**		**-**	**-**
CO 5	**-**			**-**	**1**	**-**	**-**

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2. Forsythe, S. J. 2008. The microbiological risk assessment of food. John Wiley & Sons.
3. Frazier, W.C. and West off D.C. 1988. Food Microbiology. TATA McGraw Hill Publishing Company Ltd. New Delhi
4. Jay, J.M. 2000. Modern Food Microbiology. 4th Edn. CBS Publishers and Distributors, New Delhi.
5. Food Safety Management Systems Achieving Active Managerial Control Of Foodborne Illness Risk Factors In A Retail Food Service Business (Pb 2020) by King H, Springer

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4. https://sites.google.com/a/uasd.in/ecourse/food-science-and-nutrition
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AGM -611AGRICULTURAL BENEFICIAL MICRO ORGANISMS (2+0)

LEARNING OBJECTIVES

- To know the concepts and potential of agriculturally important organisms.
- To acquire the basic knowledge about the importance of microbes in agriculture.
- To impart knowledge of beneficial microbes in farming system.
- To understand and develop skills about organic agriculture.
- To create awareness about the importance of beneficial organisms.

UNIT-1 HISTORY AND DEVELOPMENT OF BENIFICIAL ORGANISMS.

History and concept of beneficial microbes, importance-scope and potential of beneficial organisms, Definition, concept and classification of beneficial microbes viz., biofertilizers, bio fungicides, bioinsecticides and probiotics.

UNIT-2MICROBIAL CONTROL OF INSECT PESTS.

Biopesticides development -virulence-pathogenicity and symptoms ofentomopathogens Viz.,*Beauveria bassiana,Metarhizumanisophilae, Paceliomyceslilacinus,Verticillium lecani*-biocontrol of nematodes- viral insecticides-*Bacillus thuringiensis*-uses of biopesticides-method of application of biopesticides. Quality control and limitations in production

UNIT 3- MICROBIAL MANAGEMENT OF PLANT DISEASES.

Biofungicide-Introduction, scope, concept and development. Characteristic features of biofungicides viz *Trichoderma viride,Trichoderma harzianum, Bacillus sp, Pseudomonas fluorescence*-current scenario-list of biofungicides- method of application of biofungicides. Quality control and limitations in production

UNIT-4 MASS PRODUCTION OF BIOFERTILIZER.

Nitrogen fixing biofertilizer-Phosphate solubilizing biofertilizer-Potassium releasing biofertilizer. Production technology of biofertilizers- strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid biofertilizers-method of application of biofertilizers. Quality control and limitations in production

UNIT-5 FORMULATIONS AND DELIVERY SYSTEM OF BENEFICIAL MICROBES.

Formulation–types–carrier based and liquid inoculants.Equipment's–tangential flow filtration (TFF)- centrifugation-freeze drying. Application technologies- dosage, method and time of application of biopesticides, bio fungicide and biofertilizers for different crops. FCO specifications and quality control.

Current stream of thoughts:

THEORY LECTURE SCHEDULE

1. History and concept of beneficial microbes
2. Importance of beneficial microbes
3. Classification of beneficial microbes.
4. Biopesticides, bio fungicides, bioinsecticides and probiotics
5. Biopesticides development
6. Virulence-pathogenicity and symptoms ofentomopathogens
7. Symptoms of entomopathogens
8. Biocontrol of nematodes.
9. **First Test**
10. Viral insecticides-*Bacillus thuringiensis*.
11. Mode of entry and mode of action biopesticides.Uses of biopesticides
12. Method of application of biopesticides.
13. Quality control of biopesticides
14. Limitations in biopesticides production.
15. Bio fungicide-Introduction, scope, concept and development
16. Characteristic features of bio fungicides
17. **Mid semester examination**
18. Current scenario-list of bio fungicides
19. Method of application of bio fungicides
20. Quality control and bio fungicides
21. Bacterial biofertilizers**.**
22. Current scenario of biofertilizers

23. Nitrogen fixing biofertilizer
24. Phosphate solubilizing biofertilizers.
25. Potassium releasing biofertilizers.
26. Production technology of biofertilizers.
27. Strain selection
28. Sterilization, growth media and fermentation.
29. Formulations in biofertilizers
30. Techniques in carrier and liquid based biofertilizers.
31. Equipment's tangential flow filtration (TFF) centrifugation-freeze drying.
32. Method of application of biofertilizers.
33. FCO specifications of biofertilizers
34. Quality control of biofertilizers, Preparation of biofertilizers projects

Course outcome:

CO 1: They will understand about the fundamental aspects, history,concepts, importance-scope and potential of beneficial microbes.

CO 2: They will acquire basic knowledge in mass production technology and quality control of beneficial microbes.

CO 3: Students will gain knowledge on individual characteristics features of beneficial microbes.

CO 4: Students will study and understand the recent techniques and developments of beneficial microbes .

CO 5: To create awareness and important of beneficial microbes in sustainable crop production

CO-PO MAPPING MATRIX

	PO1	PO2	PO3	PO4	PO5
CO1	**2**	**-**	**1**	**1**	**1**
CO2	**3**	**1**	**-**	**2**	**3**
CO3	**1**	**-**	**3**	**1**	**2**
CO4	**-**	**2**	**2**	**-**	**-**
CO5	**1**	**2**	**3**	**2**	**1**

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1. Acharya, K. Surjith Sen and Manjula Rai. 2019. Biofertilizers and Biopesticides Techno world.
2. Chanda J. K. 2008. Biofertilizer Statistics 2006-07. The fertilizer Association of India, New Delhi.
3. DeshMukh, AM, R.M. Khobragade and P.P. Dixit 2007. Handbook of Biofertilizers and Biopesticides. Oxford Book Company, Jaipur, India.
4. Gupta R.P., AnuKalia and Shammi Kapoor 2007. Bioinoculants a step towards Sustainable Agriculture, NIPA, New Delhi
5. Somani L.L. P, Shilkar& D. Shilpkar 2011. Biofertilizers Commercial Production Technology & Quality control. Agro Publishing Acadamy, Udaipur.

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3. **www.nabard.org**
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COM 611 Advances in Computer Applications (1+1)

OBJECTIVES

- After completion of this unit of module, candidate will be able to
- Gain the knowledge about documentation on open source tool.
- To understand the Working knowledge of Latex typesetting language
- Understand features of Python that make it one the most popular languages in the industry.
- Understand the areas where Python is used.

THEORY

Unit I Introduction to Latex:

Introduction to Latex – What is Latex – Document Structure, Start Text works, Title, Section, Table of content – Typesetting Text, Font Effects, Coloured Text, Font Size, List, Comments & Spacing, Special Charcters.

Unit II Packages and Classes in Latex:

Inserting Equations – Mathematical Symbols – Table of Content – Generating New Command – Figure handling numbering, List of figure, List of Tables.

Packages – Geometry, Hyperref, amsmath, amssymbol – Classes – Article, Book, Report - The BibTex file – Inserting Bibliography – Citing – References.

Unit III MS Access:

MSACCESS: Database, concepts and types - Uses of DBMS in Agriculture; creating database.

Unit IV Introduction to Python:

Python Introduction, Technical Strength of Python, Introduction to Python Interpreter and program execution, Using Comments, Literals, Constants, Python's Built-in Data types, Numbers (Integers, Floats, Complex Numbers, Real, Sets), Strings (Slicing, Indexing, Concatenation, other operations on Strings), Accepting input from Console, printing statements, Simple 'Python' programs.

Unit V Using Databases in Python:

Database Programming: Connecting to a database, Creating Tables, INSERT, UPDATE, DELETE and READ operations, Transaction Control, Disconnecting from a database.

LECTURE SCHEDULE

1. Introduction to Latex.
2. Document Structure.
3. Classes.
4. Typesetting Text.
5. Inserting Equations
6. Packages and Mathematical Symbols.
7. List of figure.
8. List of Tables.
9. Bibliography and References.
10. **Mid Semester Examination**
11. MS Access Concepts of Database, Creating Database.
12. DBMS in Agriculture.
13. Introduction to Python.
14. Built-in Data types.
15. Strings.

16. Python Console.
17. Database in Python.

PRACTICALS SCHEDULE

1. Installation of Latex, Basic Latex commands.
2. Latex Compilation, Page Layout.
3. Building a Latex document, Previewing first.tex.
4. Addition of some text in the.tex file, Finding the error and fixing it.
5. Type setting of mathematics, Writing equations, matrix.
6. Two figure next to each other, Formation of table
7. Typesetting with a new chapter heading, List of figures, List of tables.
8. Citation, Bibliography, printing your document
9. MSACCESS: Creating Database, preparing queries and reports.
10. MSACCESS: Demonstration of Agri-information system.
11. Introduction to Python, Working with Data.
12. Program Organization, Functions, and Modules, Classes and Objects.
13. Inside the Python Object System.
14. Testing, Debugging, and Software Development Practice.
15. Packages.

COURSE OUTCOMES

At the end of the course students will be able to

CO 1: Problem solving and programming capability.
CO 2: Analyse common problems using Latex.
CO 3: Learn categories of programs.
CO 4: Construct and execute basic programs in Python..
CO 5: Use external libraries and packages with Python.

CO-PO MAPPING MATRIX

	PO 1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	0	1	3	1	2	2
CO3	0	3	2	3	2	2
CO4	3	0	0	0	3	0
CO 5	0	3	2	0	1	3

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2. LaTeX: A Document Preparation System, 2nd Edition By Leslie Lamport
3. Charles Dierbach, "Introduction to Computer Science using Python", Wiley, 2015
4. Python Programming- A modular Approach (with Graphics, database, Mobile and Web Applications by Sheetal Taneja and Naveen Kumar, Pearson.
5. Head First Python by Paul Berry, O'Reilly

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4. https://devfreebooks.github.io/python/

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