MASTER’S PROGRAMME

A Master’s Programme consists of a number of courses. Master’s Programme consists of a set of Core Courses and elective Courses.

Core courses are basic courses required for each programme. The number and distribution of credits for core courses will be decided by the faculty.

Elective courses will be suggested by the respective departments, and they may be distributed in III and IV semesters.

A course is divided into five units to enable the students to achieve modular and progressive learning.

SEMESTERS

An academic year is divided into two semesters, Odd Semester and Even Semester. The normal semester periods are:

Odd Semester: July to November (90 Working days)

Even Semester: December to April (90 Working days)

CREDITS

The term credit is used to describe the quantum of syllabus for various programmes and hours of study. It indicates differential weightage given according to the contents and duration of the courses in the curriculum design.

The minimum credit requirement for a two year Master’s Programme shall be 94.

The core courses shall carry 88 credits and the elective courses shall carry 6 credits.
ELIGIBILITY


COURSES

Each course may consist of lectures / laboratory work / seminar / project work / practical training / report / viva voce etc.

COURSE WEIGHT

Core and elective courses may carry different weightage. For example, a course carrying one credit for lectures, will have instruction of one period per week during the semester, if three hours of lecture is necessary in each week for that course then 3 credits will be the weightage. Thus normally, in each of the courses, credits will be assigned on the basis of the lectures / laboratory work and other form of learning in a 15 week schedule:

(i) One credit for each lecture period per week.
(ii) One credit for every three periods of laboratory or practical work per week.
(iii) One credit for 3 contact hours of project work in a week.
(iv) One credit for every two periods of seminar.

GRADING SYSTEM

The term Grading System indicates a 10-point scale of evaluation of the performance of students in terms of marks, grade points, letter grade and class.

DURATION

The duration for completion of a two year Master’s Programme is four semesters.

STRUCTURE OF THE PROGRAMME

The Master’s Programme will consist of:

(i) Core courses which are compulsory for all students.
(ii) Elective courses which students can choose from amongst the courses offered the faculty as well as by Departments of other faculties (Arts, Science, Education and Indian Language).
(iii) The Elective subjects will be allotted by counseling by a committee of the respective Heads of the Departments under the Chairmanship of the Dean of the Faculty.

(iv) Dissertation / Project work / Practical training / Field work can be done in an organization (Government, Industry, Firm, Public Enterprise etc.) approved by the concerned department.

ATTENDANCE

Every teaching faculty handling a course shall be responsible for the maintenance of attendance register for candidates who have registered for the course.

The teacher of the course must intimate the Head of the Department at least Seven Calendar days before the last instruction day in the semester about the attendance particulars of all students.

Each student should fulfil the attendance requirement of 75% as prescribed by the University, to be eligible to appear for the University Examinations.

EXAMINATIONS

The internal assessment for each course carries 25% marks and is based on two sessional tests. The pattern of question paper will be decided by the faculty. The tests are compulsory.

There will be one End Semester Examination (75% marks) of 3 hours duration for each course. The pattern of question paper will be decided by the faculty.

The Internal assessment for each practical course carries 40% of marks; while the end semester practical examination of 3 hours duration carries 60% of marks.

EVALUATION

The performance of a student in each course is evaluated in terms of Percentage of Marks (PM) with a provision for conversion to Grade Point (GP). The total performance in each semester will be rated by Grade Point Average (GPA) while the continuous performance from the 2nd Semester onwards will be marked by Overall Grade Point Average (OGPA).

MARKS AND GRADING

A student cannot repeat the assessment of Sessional Test I and Sessional Test II. However, if for any compulsive reason, the student could not attend the test, the prerogative of arranging a special test lies with the teacher in consultation with the Head of the Department.

A student has to secure 50% minimum in the End Semester Examination.

The student who has not secured a minimum of 50% of marks (sessional plus end semester examination) in a course shall be deemed to have failed in that course.

A candidate who has secured a minimum of 50% marks in all the papers prescribed in the programme and earned a minimum of 94 credits will be considered to have passed the Master’s Programme.
GRADING

A ten point rating scale is used for the evaluation of the performance of the student to provide letter grade for each course and overall grade for the Master’s Programme.

<table>
<thead>
<tr>
<th>Marks</th>
<th>Grade</th>
<th>Letter grade</th>
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<tr>
<td>90 and Above</td>
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</tr>
<tr>
<td>85 – 89</td>
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<td>D</td>
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<tr>
<td>80 – 84</td>
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</tr>
<tr>
<td>70 – 74</td>
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<td>7.0</td>
<td>A</td>
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</tr>
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<td>60 – 64</td>
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<tr>
<td>55 – 59</td>
<td>6.0</td>
<td>B</td>
<td>Second Class</td>
</tr>
<tr>
<td>50 – 54</td>
<td>5.5</td>
<td>C</td>
<td>Second Class</td>
</tr>
<tr>
<td>49 or Less</td>
<td>-</td>
<td>F</td>
<td>Fail</td>
</tr>
</tbody>
</table>

The successful candidates are classified as follows:

I Class – 60% Marks and above in overall percentage of Marks (OPM).

II Class – 50-59% Marks in overall percentage of marks.

Candidates who obtain 75% and above but below 90% of marks (OPM) shall be deemed to have passed the examination in FIRST CLASS (Distinction) provided he / she passes all the papers prescribed for the programme at the first appearance.

For the Internal Assessment Evaluation, the details shall be as follows:

| Test (2 tests) | 15 |
| Assignment    | 5  |
| Seminar       | 5  |
| Total         | 25 Marks |

COURSE – WISE LETTER GRADES

The percentage of marks obtained by a candidate in a course will be indicated in a letter grade.

A student is considered to have completed a course successfully and earned the credits if he / she secures an overall letter grade other than F. A letter grade F in any course implies a failure in that course. A course successfully completed cannot be repeated for the purpose of improving the Grade point.

The F grade once awarded in the grade card of the student is not deleted even when he / she completes the course successfully later. The grade acquired later by the student will be indicated in the grade sheet of the odd / even semester in which the candidate has appeared for clearance of the arrears.
A student who secures F grade in any course which is listed as a core course has to repeat it compulsorily when the examination is held next. If it is an Elective course, the student has the option to repeat it when it is offered next or to choose a new elective if he / she so desires in order to get a successful grade. When new elective is chosen in the place of failed elective, the failed elective will be indicated as dropped in the subsequent grade card.

If a student secures F grade in the Project Work / Field Work / Practical Work / Dissertation, he / she shall improve it and resubmit it if it involves only rewriting incorporating the clarifications of the evaluators or he / she can re-register and carry out the same in the subsequent semesters for evaluation.
# M. Sc., COASTAL AQUACULTURE  
(M. Sc., BRANCH VII - B)  
CHOICE BASED CREDIT SYSTEM 2018 – 2019

## I SEMESTER

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CAQC 101</td>
<td>Fundamentals of Marine Biology and Oceanography</td>
</tr>
<tr>
<td>CAQC 102</td>
<td>Nutrition and Biochemistry</td>
</tr>
<tr>
<td>CAQC 103</td>
<td>Physiology, Cytology and Genetics</td>
</tr>
<tr>
<td>CAQC 104</td>
<td>Aquaculture Engineering</td>
</tr>
<tr>
<td>CAQC 105</td>
<td>Aquarium Keeping and Management</td>
</tr>
<tr>
<td>CAQC 106</td>
<td>Computer Application - I</td>
</tr>
<tr>
<td>CAQC 107</td>
<td>Communication Skills</td>
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<tr>
<td>CAQP 108</td>
<td>Practical – I (CAQC 101)</td>
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<td>CAQP 109</td>
<td>Practical – II (CAQC 102)</td>
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<td>Practical - IV (CAQC 104)</td>
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<tr>
<td>CAQP 112</td>
<td>Practical – V (CAQC 105)</td>
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## II SEMESTER

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<td>Biology and Culture of Crustaceans</td>
</tr>
<tr>
<td>CAQC 202</td>
<td>Biology and Culture of Finishes</td>
</tr>
<tr>
<td>CAQC 203</td>
<td>Biology and Culture of molluscs and Seaweeds</td>
</tr>
<tr>
<td>CAQC 204</td>
<td>Health management in aquaculture systems</td>
</tr>
<tr>
<td>CAQC 205</td>
<td>Post Harvest Technology</td>
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<tr>
<td>CAQP 206</td>
<td>Practical – VI (CAQC 201)</td>
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<td>CAQP 207</td>
<td>Practical – VII (CAQC 202)</td>
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<tr>
<td>CAQP 208</td>
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## III SEMESTER

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<td>CAQC 302</td>
<td>Biotechnology and Applied Marine Biology</td>
</tr>
<tr>
<td>CAQC 303</td>
<td>Aquaculture Information, Economics &amp; Extension</td>
</tr>
<tr>
<td>CAQC 304</td>
<td>Bioentrepreneurship</td>
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<tr>
<td>CAQC 305</td>
<td>Elective – I</td>
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<tr>
<td>CAQP 306</td>
<td>Practical – XI (CAQC 301)</td>
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<td>CAQP 307</td>
<td>Practical – XII (CAQC 302)</td>
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## IV SEMESTER

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<td>CAQC 402</td>
<td>Project Work</td>
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### M.Sc. COASTAL AQUACULTURE (Two year CBCS)

**CREDITS, INTERNAL ASSESSMENT MARKS AND END SEMESTER EXAM MARKS**

<table>
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<th>Course Code</th>
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<td><strong>III SEMESTER</strong></td>
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<td>CAQC 301 Instrumentation and Analytical Methods</td>
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Students have to choose courses for 6 credits (2 courses) out of the elective courses offered in other departments / faculties of the University. The elective papers are for students of other departments / faculties of the University.

<table>
<thead>
<tr>
<th>Credit</th>
<th>Core</th>
<th>Elective</th>
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<tbody>
<tr>
<td>88</td>
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</tbody>
</table>

**SUGGESTED ELECTIVES**

1. Marine Food Technology
2. Marine Pharmacology
3. Plant and Animal Cell Culture Technology
4. Microbial Technology
5. Bioprocess Engineering & Technology
6. Biostatistics
7. Genomics & Proteomics
8. Vaccines
9. Molecular Virology
I SEMESTER

CAQC101 : FUNDAMENTALS OF MARINE BIOLOGY AND OCEANOGRAPHY

Objectives:

A Complex variety of environment for living organisms is provided by the Oceans and Coastal Seas of the world. Marine Biology is an interdisciplinary Science, an introductory marine biology course will help develop a broad conceptual framework for understanding the geographical, physical and chemical aspects related to marine organisms and their environment. Such understanding of the marine environment and organisms living there would be very useful as some of these organisms are candidate species for aquaculture. Selecting suitable candidate species and the success of their culture could be enhanced by acquiring knowledge of the environment they live in. Therefore this paper would form a very important basis for a course in coastal aquaculture.

UNIT I: Ocean – General

Classification of coastal environment – marine, brackish, estuarine, mangroves, lagoons and coral reefs – their physico – chemical features.

UNIT II: Oceanography

Basic concepts in physical, chemical and biological oceanography. Sea as a biological environment.

UNIT III: Plankton


UNIT IV: Benthos

Benthos – classification, methods of sampling and biomass estimation, adaptations of benthic forms.

UNIT V: Resources - Pollution

Resources of marine environment – commercially important finfish, shellfish, algal resources – Non- living resources – minerals, salts, petroleum and natural gas, Drug from the seas.

Marine pollution types – sewage, hydrocarbons, pesticides, heavy metals, thermal, oil radioactivity.
PRACTICAL I : CAQP 108 - Fundamentals of Marine Biology & Oceanography

2. Zooplankton – collection, estimation, identification of major groups and biomass analysis.
3. Benthos – collection, qualitative and biomass analyses
4. Analyses of water qualities
   - Salinity
   - Dissolved Oxygen
   - Nutrients
   - pH
   - BOD and COD
   - H₂S and Ammonia
5. Identification of commercially important fin and shell fishes, algae especially medicinally important algae, mangroves, animals etc (Snakes, Corals, Sponges etc).

REFERENCE BOOKS

Objectives:

As the natural fishery resources are dwindling day by day, the aquaculture is the only alternative to compensate the protein paucity of the exploding human population. In any aquaculture practice, the feed and seed are the two important factors that control the whole venture. Further, the cultivable species of fin and shell fishes (larvae, juveniles and adults) prefer live as well as formulated feeds. Besides, the above, the digestion and assimilation of the feed is so important which influences the growing animal in almost all the ways. Hence the paper on ‘Nutrition and Biochemistry” has been introduced into the curriculum with the objectives of understanding the importance of nutrition in aquaculture, knowing the technical - know – how in the formulation of various artificial feeds, having a knowledge on the various formulated and live feeds used and understanding the metabolism of the feed taken by the animal.

UNIT 1: Nutrition

Aquaculture nutrition - an Overview, proteins, amino acids, lipids and fatty acids, carbohydrates and carotenoids - their importance in the nutrition of fin and shellfish, role of vitamins and minerals.

UNIT 2: Feed ingredients and feed formulation

Ingredients – conventional and non – conventional, their nutritive value, feed formulation methods, binders, water stability of feed, use of attractants in feeds, importance of anabolic agents – antioxidants and mould inhibitors, anti – nutritional factors – other additives.

UNIT 3: Types of Feed, Feed storage and evolution

Different types of formulated feeds – pellets - dry feed, wet feed, floating feed, flakes, microparticulate and microencapsulated diets, storage and quality control. Determination of energy content in feeds, FCR and energy budget.

UNIT 4: Live feed

Methods of collection of live food organisms, identification, isolation and maintenance of phytoplankton, mass culture of phytoplankton and zooplankton (Brachionus, Copepods and Moina), culture of Artemia, production of cyst and their utilization.

UNIT 5: Biochemistry

Carbohydrate, protein and fat; enzymes – classification, factors influencing enzyme activity, role of enzyme in food processing.
1. Formulation and preparation of artificial feeds for finfish and shrimps
2. Determination of food intake and digestibility coefficient
3. Culture of live – feed organisms (Phytoplankton and zooplankton)
4. Estimation of the following in the feed ingredients and feeds:
   - Carbohydrates by Colorimetric method
   - Proteins by Colorimetric method
   - Use of Spectrometer
5. Chromatographic separation of free amino acids and carbohydrates by ascending, descending and circular paper chromatographic techniques
6. Chromatographic separation of lipids by T.L.C.
7. Estimation of moisture and lipid content
8. Electrophoretic separation of protein

REFERENCE BOOKS

CAQC 103 – PHYSIOLOGY, CYTOLOGY AND GENETICS

Objectives:

The objective of the paper is to teach the post graduate students of coastal aquaculture about the physiological mechanisms involved during digestion, respiration, excretion and biological behavior etc. in marine animals, structural and functional aspects of cells of marine organisms and to apply the principles of genetics for yielding higher production of marine organisms during culture.

UNIT 1: Physiology - General

Introduction to physiology, physiology of respiration – respiratory organs, mechanism of ventilation, respiratory pigments and gaseous exchange mechanism, physiology of digestion – enzymes and their role in food conversion processes.

UNIT 2: Osmoregulation


UNIT 3: Biorhythms

Physiological rhythms in marine animals – circadian, tidal and lunar rhythms, reproductive and behavioural rhythms, physiological changes during rhythms.

UNIT 4: Cytology

Types of cells and tissues – cytoplasmic inclusion at ultrastructural level, nucleus and nuclear components, nuclear envelope, cell divisions, chromosome preparation - methodology.

UNIT 5: Genetics

Principles of genetics, interactions and environmental influences, practical application of genetics – hybridization of fishes, recent trends and techniques in hybridization, selective breeding, cross breeding, development of disease resistance and high quality of new strains, transgenic fish production.

Chromosome manipulation, its role in aquaculture, androgenesis, gynogenesis, sex reversal and tripoidy, cryopreservation and conservation of germplasm. Transgenic fish.
PRACTICAL III - CAQP 110 – Physiology, Cytology and Genetics

1. Estimation on oxygen consumption and rate of respiration in a fish or a crab
2. Effect of hydrogen – ion concentration on amylase activity of the crystalline style
3. Effect of temperature and salinity on respiration of a fish or a crab
4. Effect of temperature – the rate of particle transport in a bivalve
5. The rate of particle filtration in bivalves
6. Hormone study – display of endocrine organs in a crustacea
7. Blood cell counts and haemoglobin estimation
8. Types of cells – study from slides
9. Mitosis – Meiosis – giant chromosomes
10. Preparation of chromosome in fishes
11. Induction of ploidy

REFERENCE BOOKS

CAQC 104 – AQUACULTURE ENGINEERING

Objectives:

Shrimp aquaculture is being practiced world wide because of its universal appearance and unique taste. Shrimp fetch demand an international market. Understanding of shrimp culture practices will be highly beneficial for the coastal aquaculture students to get themselves placed in this industry.

Unit I

Principles of fish farm engineering – site selection – technical considerations – topography soil type, water supply, quality and dynamics.

Non-technical considerations – socio-economic, political and legal aspects.

Unit II

General principles and procedures of elementary engineering survey, planning of survey in coastal region, computation of area.

Unit III

Requirements of a brackishwater farm. Pond – its types, size, shape, design; Dyke – types, size and shape; Inlet and Outlet structures – types and design; supply and drainage canals – design and construction, operation and maintenance of farms.

Unit IV

Water supply to fish farm – controlling devices of flow, pump types – aerating equipments and filtration systems.

Unit V

Open sea – farming – site selection, Constraints and prospects of open sea farming – Culture in Cages, Pens, rafts rack and raceways: design, construction, repairing and maintenance. This paper is focussed mainly on the site selection farm designing, construction and different types of farming practices.
PRACTICAL IV : CAQP 111: AQUACULTURE ENGINEERING

1. Survey of sites and topography studies
3. Survey of Water potentials and water quality characteristics
4. Measurement of velocity and discharge of tidal channel
5. Field visit to study the components of a brackishwater farm system
6. Drawing of layout of the farm visited
7. Observations / operation of pumps, aerators, feeding trays, etc.

REFERENCE BOOKS

CAQC 105 – AQUARIUM KEEPING AND MANAGEMENT

Objectives:

Aquarium keeping is worldwide hobby and the production of ornamental fishes is a multi-billion dollar business. This paper deals with all aspects covering right from the aquarium components to the management of the aquarium. At the end of the course the post graduate students shall be well versed in not only the setting up of aquarium but also the successful maintenance.

Unit I - Introduction


Unit II - Indoor aquarium

Tank designs – fabrication of tanks – choosing the right tank – buying and locating a tank.

Unit III Aeration and filtration


Unit IV - Setting up an aquarium


Unit V – Health Management


PRACTICAL V : CAQP 112 : Aquarium Keeping and Management

1. Identification of common marine and freshwater aquarium fishes
2. Identification of common ornamental aquatic plant species.
3. Fabrication technique of glass aquarium tank
4. Operation of aquarium equipment and accessories
5. Conditioning and packing live aquarium species
6. Culture of live feed organisms
7. Breeding of live bearers
8. Breeding of egg layers
9. Identification and treatment of common ornamental fish diseases
10. Demonstration of Setting up of hi-tech aquarium tank
11. Field visits to commercial ornamental fish breeding farms

REFERENCE BOOKS

CAQC 106 – COMPUTER APPLICATION - I

Objectives:

This course will offer exposure to the hardware, terminology and functions of the personal computer. Hands on experience using popular software will allow exploration and basic introduction to windows and word processing. It also offers internet, web designing and multimedia operations.

UNIT – I


UNIT – II


UNIT – III


Fundamentals of HTML, TCP/IP and E-commerce.

UNIT – IV


UNIT – V


Using Multi Media: Multimedia Interface, Planning and Development of Multimedia projects.
REFERENCE BOOKS

4. James Meade, David Growder, Rhonda Growder – Microsoft DHTML.
CAQC 107 - COMMUNICATION SKILLS

Unit - I

Process of communication

Concept of effective communication- Setting clear goals for communication; Determining outcomes and results; Initiating communication; Avoiding breakdowns. Creating value in conversation; Barriers to effective communication; Non verbal communication- Interpreting non verbal cues; Importance of body language, Power of effective listening; recognizing cultural differences.

Unit - II

Presentation skills
Formal presentation skills; Preparing and presenting using Over Head Projector, Power Point; Defending Interrogation; Scientific poster preparation and presentation; Participating in group discussions.

Unit - III

Technical Writing Skills
Types of reports; Layout of a formal report; Scientific writing. Problems in the preparation of a scientific document; Plagiarism; Scientific Publication Writing: Elements of a Scientific paper including Abstract, Introduction, Materials and Methods, Results, Discussion, References; Drafting titles and framing abstracts.

Unit - IV

Computing Skills for Scientific Research
Web browsing search engines Hidden Web and its importance in Scientific research; Internet as a medium of interaction of scientists; Effective e-mail strategy using the right tone and conciseness.

REFERENCE BOOKS

II SEMESTER

CAQC 201 – BIOLOGY AND CULTURE OF CRUSTACEANS

Objectives:

Shrimp aquaculture is being practiced worldwide because of its universal appearance and unique taste. Shrimp fetch demand an international market. Understanding of shrimp culture practices will be highly beneficial for the coastal aquaculture students to get themselves placed in this industry. Thus this paper is focused on the biological aspects, farming practices and management of crustaceans including shrimps, crabs and lobsters. In this paper the students are also taught how to estimate the production and work out the economics.

UNIT I

An overview of Crustacean culture – historical background, general review and present status of culture of shrimps, lobsters and crabs and freshwater prawns in India and abroad. Important areas of culture, species of crustaceans cultured in different regions of the world and India, production and its trend.

UNIT II

Moulting – different stages of moulting, its influence on growth, interaction with reproduction and endocrine control of moulting.

Collection of brood stock and transportation, breeding under controlled conditions, brood stock development and management techniques of induced breeding. Hatchery production of seed, types of hatcheries, components of a hatchery - Nursery management and Feeding schedule.

UNIT III

Field culture – traditional culture practices prevailing in India and in other countries, advantages and disadvantages of these practices. Culture of Penaeus monodon, P.indicus and P.vannamei.

Extensive, semi – intensive and intensive cultures - their management practices.

Unit IV

Culture of freshwater prawn Macrobrachium spp. and its seed production

Culture of lobsters and crabs in India and elsewhere – prospects and constraints.

Unit V

Production and economics - Shrimps and Macrobrachium culture in extensive and semi – intensive systems.
PRACTICAL VI : CAQP 206 : Biology and Culture of Crustaceans

1. Collection and identification of prawns, shrimps, lobster and crab seeds from nature by using different nets.
2. Identification of larval forms of shrimp, prawn and crab from plankton collection
3. Technique of induced breeding and rearing of eggs through larval and postlarval stages to stocking size, counting methods of eggs and nauplii in a hatchery.
4. Study of hatchery facilities like tanks, pumps, aerators, filters etc. in prawn hatcheries.
5. Determination of stocking density, techniques of field culture operation and monitoring of the stocked prawn through demonstration and field visits.
6. Recording and maintenance of data in a prawn and shrimp farms.
7. Field visit to observe harvesting operation, recording of data of production estimation.
8. Visit to sea food processing unit.
9. Visit to CIBA to see sea bass culture technology and feed mill etc.
10. Identification of males and females in commercially important fishes.
11. Hypophysation technique.

REFERENCE BOOKS

CAQC 202 – BIOLOGY AND CULTURE OF FINFISHES

Objectives:

The objective of the paper is to teach the post graduate students of coastal aquaculture about biology and culture of fin fishes. Without understanding the biology of finfishes culturing them is highly impossible scientifically. Therefore, the present paper deals both biology and culture together. This paper is planned to teach in the lines of understanding the candidate species of important cultivable finfishes, gaining knowledge in the food and feeding habits and life history of the candidate species, investigating the natural seed potential and artificial fish seed production through hatcheries, fish farm management and their detailed methods of farming, giving information on market value of fishes and their cost of production and providing scope for employment opportunities in aquaculture activities.

UNIT I: Finfish biology

Biology of cultivable finfishes - Life history – food and feeding – age & growth – reproduction

UNIT II: Seed

Seed production - distribution and abundance, methods for resource assessment and collection of seeds. packing and transportation.

UNIT III: Hatchery

Types of fish hatcheries – Fish hatchery components.

Artificial production of seed, breeding under controlled conditions, techniques induced breeding, egg incubation and larval rearing procedures and systems. Hatchery production of seeds, packing and transport of brooders and seeds.

UNIT IV: Fin fish Culture

Culture practices in ponds of important finfish species, preparation and management of nursery and grow – out ponds, eradication of undesirable organisms, nursery technique, pond fertilization, stocking, feeding and provision for removal of metabolites.

UNIT V: Polyculture

Polyculture – species selection for polyculture, criteria and characteristics of species selected for polyculture, stocking density and ration, feeding and management.

Ornamental fish culture

Ornamental fish culture. Production and economics – optimal size for harvesting, methods of harvesting economics.
PRACTICAL VII : CAQP 207 - Biology and Culture of Finfishes

1. Identification of fish eggs and larvae from plankton collection
2. Collection and identification of seeds from wild using different gears and seed resource survey.
3. Identification of important cultivable species and common ornamental fishes.
4. Techniques of induced breeding – dissection, preservation and demonstration of pituitary gland in alcohol and glycerol, rearing of eggs and larvae.
5. Observation on the management practices of nursery and stocking ponds, stocking density.
6. Field visit to finfish culture systems and submission of report
8. Methods of transport of seeds and brooders.

REFERENCE BOOKS


Objectives:

In India, the culture of molluscs and Seaweeds is in its growing stage, though these two groups (Molluscs and Seaweeds) include many cultivable important species. Further, for the culture of any group of organism/plant the basic knowledge about its biology becomes imperative. Hence the paper on “Biology and culture of molluscs and Seaweeds” has been included in the curriculum with the objectives of understanding the biology pertaining to food and feeding, reproduction and age and growth of the cultivable important species, knowing and estimating the distribution and seed resources in the natural environment, studying the technology involved in the artificial seed production of the cultivable important species and understanding the various techniques involved in the culture of molluscs (Clams, cockles, mussels and Oysters) and Seaweeds.

UNIT 1: Biology - molluscs

Biology of cultivable molluscs – life history, food and feeding, age and growth and reproduction.

UNIT 2: Seed from Nature

Natural seed resources, utilization, ideal condition for seed fall in nature, distribution of seed, time of seed abundance, seed collection techniques for different species, transportation, seed quality and selection.

UNIT 3: Hatchery

Hatchery production of molluscan seed - need for hatcheries for molluscs, brood stock management, induced maturation and spawning, larval rearing & microalgal culture for feeding spat settlement, ideal spat collectors, rearing of juveniles to stockable size, water quality management, transportation.

UNIT 4: Culture

Culture technology – culture operations, rearing, transportation, monitoring of growth, monitoring of environmental parameters, causes of mortality, different culture techniques and various steps involved in detail and problems encountered on the culture of clams, cockles, edible oyster, pearl oyster and mussel, economic importance of molluscs.

UNIT 5: Seaweeds


Culture:

Seaweed culture – technology for higher yields, products from seaweeds (agar, algin and carageenan) and extraction methods, production and economics of seaweed culture, economic importance of seaweeds.
PRACTICAL VIII : CAQP 208 : Biology and Culture of Molluscs and Seaweeds

2. Farm visit to witness seeding, growth, measurement, thinning, harvesting and in situ measurements of production.
3. Induction of spawning by physical, chemical and biological techniques.
4. Identification of locally available seaweeds.
5. Demonstration of algin and agar extraction.
6. Field visit to observe the culture of seaweeds and the technique of harvest.
7. Submission of field report.
8. Identification of males and females in commercially important hypophy technique

REFERENCE BOOKS


CAQC 204 – HEALTH MANAGEMENT IN AQUACULTURE SYSTEMS

Objectives:

Marine microbes play a major role in causing diseases in capture and culture fisheries. For sustainable development of the aquaculture, a thorough understanding of microbial pathogens and their control are necessary.

UNIT 1: Microbiology

General introduction to marine microbiology and pathology – their importance in aquaculture system – Health management in aquaculture system.

UNIT 2: Methods: Isolation and Culture

Methods of studying the coastal microorganisms – methods of collection of water, sediment, finfish and shellfish samples, isolation and culture of bacteria, enumeration, total and viable counts, identification of bacteria based on their morphological, physiological and biochemical characteristics.

Microbial nutrition, influence of environmental factors on microbial growth and activity, structure and biology of bacteria and viruses.

Role of microorganisms in the cycling of minerals – sulphur cycle, nitrogen cycle and phosphorus cycle, probiotics.

UNIT 3: Diseases – Finfishes

Disease development factors involved, abiotic and biotic.

Detailed study on diseases of finfish (food fishes) – viral, bacterial, fungal, parasitic (protozoan & metazoan), environmental and nutritional diseases.

Diseases of ornamental fishes.

UNIT 4: Diseases – Shell fishes

Detailed study on shellfish diseases (shrimp, lobster, molluscs) – viral, bacterial, fungal, parasitic (protozoan & metazoan), environmental and nutritional diseases.

Larval health monitoring with special reference to shrimps and fishes.

Modern techniques employed in diagnosis of diseases in cultivable organisms with special reference to shrimps, WSSV sample collection and preparation for different techniques (microbiology, immune studies)

UNIT 5: Diseases – Prevention

Prevention of diseases – Good management procedure (GMP) - environmental and physical methods, chemical methods, biological methods.
Salinity practices and prophylactic measures – in hatcheries and grow out ponds, disinfection procedures, water quality standards and their levels associated with fish health and disease, common chemicals and antibiotics in use, toxic substances damaging fish health.

Immune mechanisms and immunization of cultivable organisms.

**PRACTICAL IX : CAQP 209 - Health Management in Aquaculture Systems**

1. Preparation of Media
2. Microbial population enumeration in water and sediment of ponds and fin and shellfish samples.
   - Pond water samples
   - Pond sediment samples
3. Isolation of pathogens from diseased specimens
6. Identification of bacteria, staining – negative, simple and gram, motility test – Hanging drop method (or) using Semisolid medium,
   - Biochemical tests – oxidase, catalase, triple sugar iron agar, decarboxylase, arginine, lysine, ornithine, indole, oxidation fermentation test, nitrate reduction test, methyl red test, voges test, proskauer test, citrate test, starch hydrolysis, gelatin hydrolysis, casein hydrolysis.
7. Antibiotic assay
8. Isolation of fungi from old stocked feeds
9. Identification of fungi
10. Larval Health monitoring – shrimp
    - Microbial load – bacteria, fungi, protozoa.
    - Physiological / physical manifestations
    - Occlusion bodies
11. Demonstration of disease symptoms through histopathological slides
12. Demonstration of dot plot and PCR

**REFERENCE BOOKS**


CAQC 205– POST HARVEST TECHNOLOGY

Objectives:

Last few decades had witnessed widespread development in the technologies for capture as well as culture of aquatic organisms world over. There is tremendous advancement in the post-harvest technology in the field of fisheries. As fish is one of the most perishable commodities, there is a need for proper preservation and processing. Pre-processed handling, processing, packaging and transportation are the essential steps involved in preservation and processing. Being a commodity of high economic value earning substantial quantum of foreign exchange, the fish and fishery products receive utmost care and importance and the scope for the further development in this sector are quite promising. The human resources development in this sector is also promising as it is a major provider of employment next only to agriculture and the much needed inexpensive wholesome protein food to the masses. With these facts in mind the syllabus has been framed to import knowledge on the entire gamut of preservation and processing.

UNIT 1: Importance of preservation and processing


UNIT 2: Fish spoilage

Types of fish spoilage, causative factors – autolytic spoilage, microbial spoilage, oxidative changes.

UNIT 3: Drying and Curing

Dehydration – conventional and modern methods of drying (Solar driers), relative merits and demerits.

Salt curing, pickling and smoking – merits and demerits.

UNIT 4: Freezing and canning

Cold storage – various types of freezers, individually quick freezing (IQF), cold storage design and equipments, freeze – drying, canning – history of canning containers, canning procedures.

UNIT 5: Fishery By-products

Fishery by – products of commerce – processing of miscellaneous products, fish meal, oil, fish protein concentrate, fish wafers, ensilage, chitosan etc., development of diversified products.

Antibiotic residue analysis – Muddy smell - marketing – export – domestic – economics. Marketing role of MPEDA.
PRACTICAL X : CAQP 210 - Post Harvest Technology

1. Field visit to different processing plant and submission of report
2. Quality Analysis in Fishes
3. Proximate composition in fresh and ice stored Fishes
   - Moisture
   - Protein
   - Ash
   - Acid insoluble ash
   - Fat
   - Peroxide value
     - Free fatty acid
     - Thiobarbitoric acid value
4. Sensory analysis in Fishes and Prawns
5. Prawns – Formulation of different products for export
   - PD
   - PUD
   - HL
   - Fillets
6. Analysis of Indole in Prawns
7. Ice storage studies – observations – nature of the eyes, gills, texture, peritonium, fibrousness, smoothness, toughness succulence.
8. pH – Fresh & Stored Fishes and Prawns.
9. Shell fish poisoning in processed fish.
10. Microbial Analysis
    - Total bacterial count
    - Coliforms
    - Staphylococcus
    - Streptococci
12. Preparation of Coated Products.

REFERENCE BOOKS


Objectives:

The main objectives of this paper are to expose students to state of the art instrumentation, to introduce them to the methods of various instruments used in aquaculture and to prepare them to use these techniques in their own research. The course is a combination of lectures and demonstrations on the principles of the instruments such different minor equipments necessary for aquaculture, microscopes, spectrophotometers and chromatographs. The laboratory work is scheduled separately for each student. The students also gain the knowledge and skill in the preparation of whole mounts. Instruments in each category are provided to work with and conduct field and laboratory trails.

UNIT 1: Field Equipments

Minor equipments – Working principles and uses of water and sediment samplers – secchi disc, lux meter, turbidity meter, pH meter, oxygen analyzer, refractometer, salinometer, echosounder.

UNIT 2: Microscopes and Centrifuge

Microscopy – light microscope, phase contrast, electron microscope, and photomicrography.

Centrifugation – Centrifugal force and principles of sedimentation, sedimentation coefficient, types of centrifuges, types of centrifugation, molecular weight determination.

UNIT 3: Spectroscopy

Absorption and emission principles – Principles and application of colorimeters, UV visible spectrophotometers, spectrofluorometer, Flame photometer, atomic absorption spectrophotometer, Inductively coupled plasma spectrometer (ICP).

UNIT 4: Electrophoresis and Chromatography

Electrophoresis: General principles – factors affecting mobility of charged molecules – principles and uses of electrophoresis, agarose gel electrophoresis, pulsed field gel electrophoresis, isoelectric focusing, polyacrylamide gel electrophoresis.

Chromatography: Paper, thin layer, gas chromatography high performance liquid chromatography, ion-exchange chromatography – principles and uses of each type.

UNIT 5 – Microtechnique

Microtechnique – sliding and rotary microtomes, freezing microtome, specimen fixation, dehydration, embedding and sectioning, staining of sections, whole mount preparation.
PRACTICAL XI : CAQP 306 - Instrumentation and Analytical Methods

1. Study of light, phase contrast & electron microscopes
2. Photomicrography
3. Measurements using microscopes- ocular & stage micrometer
4. Preparation of whole mount
5. Paper Chromatography
6. Thin layer Chromatography
7. Electrophoresis

REFERENCE BOOKS

Objectives:

The improvement of the production, quality and other important traits of cultivable organisms is possible through the improvement of the system of culture and management practices followed in one hand and in the other hand the quality improvement is possible by employing certain biotechnological tools and improving the genetic makeup. Further the many of the organisms are the storehouses of some biologically important substances. In this context the present paper has been designed to teach the student about the various techniques, methodologies involved in the health management etc.

UNIT 1: Genetics

Application of genetics, coastal aquaculture - genetic engineering and biotechnology in marine organisms.

UNIT 2: Pharmacology


UNIT 3: Immunology

Disease diagnosis – concepts, ELISA, dot immunobinding, western blotting, latex agglutination test, monoclonal antibodies – DNA based diagnosis of diseases, fish vaccines.

UNIT 4: Biotechnology

Rural and industrial biotechnologies – cell and tissue culture, microbial biofertilizers, microbial enzymes, fermentation, effluent treatments, biocorrosion, biofouling.

UNIT 5: Uses

Production of biological systems for commercial utility;

PRACTICAL XII : CAQP 307 - Biotechnology and Applied Marine Biology

1. Visit to biotechnology industries / Laboratories
2. ELISA test
3. Amplification of DNA
4. Gel electrophoresis
5. Cell and tissue culture
6. Chromosome studies

REFERENCE BOOKS


Objectives:

This paper is very useful to the candidates for self employment. It deals with important aspects like, how to avail land?. How to register a farm, hatchery? etc., starting from soil culture till harvest the steps involved are discussed. Further, extension education, marketing, techniques were given in this paper.

UNIT 1: Registration

Land leasing polices of maritime states, setting – up of a aquaculture farm in practice how to go about, purchase of land, registration, registration in MPEDA / BFDA for getting subsidy and technical guidance, getting electric connection and other practical considerations.

UNIT 2: Funds

Role of financial institutions – availing bank loan – formalities to be followed.

Role of insurance companies – formalities to be followed for getting insurance cover and preparation of claim for loss.

UNIT 3: Data

Data base collection and Data processing : Data collection in different aquaculture practices - Traditional, extensive, semiintensive and intensive culture.- Relative economic model for the different practices.

UNIT 4: Information


UNIT 5: Extension


Status of extension activities, transfer of technology, behavioural pattern of fishermen to structural changes, adoption of villages for integrated rural development, socio – economics, marketing, internal and external markets and trade, demand and supply.
PRACTICAL XIII : CAQP 308 - Aquaculture Information, Economics and Extension

1. Visit of fishermen co-operative society.
2. Visit to aquaculture farms.
3. Income statement analysis.
4. Preparation of farm plans and budgets.
5. Preparation leaflets, folders, pamphlets, circular letter, poster, charts etc for fisheries extension activities.
6. Preparing and practicing a script for radio talk and public speaking.
7. Training to get license, Subsidy and from the Government.
8. Identification of fishes for Integrated farming.
9. Estimation of Ammonia, Hydrogen sulphide and organic matter
10. Identification of Zeolite and lime used in aquaculture.
11. Submission of field report.

REFERENCE BOOKS

Objectives:

This paper deals with all the aspects of accounting to marketing. The content of this paper trains and prepares the post graduate students in the above aspects to take up any position in the field of aquaculture and aquaculture related product’s marketing.

Unit I: Accounting and Finance

Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; Approach a bank for a loan; Sources of financial assistance; Making a business proposal/Plan for seeking loans from financial institution and Banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management; Basics in accounting practices: concepts of balance sheet, P&L account, and double entry bookkeeping; Estimation of income, expenditure, profit, income tax etc.

Unit II: Marketing & Negotiations/Strategy

Assessment of market demand for potential product(s) of interest; Market conditions, segments; Prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/ Advertising; Services Marketing

With financiers, bankers etc.; With government/law enforcement authorities; With companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/ Avoiding/Managing; Broader vision–Global thinking

Unit III: Information Technology

How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E-business setup, management.

Unit IV: Human Resource Development (HRD)

Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.

Unit V: Fundamentals of Entrepreneurship & Role of knowledge centre and R&D

Support mechanism for entrepreneurship in India

Knowledge centres like universities and research institutions; Role of technology and upgradation; Assessment of scale of development of Technology; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.
Practical Case Study

1. Candidates should be made to start a ‘mock paper company’, systematically following all the procedures.
   • The market analysis developed by them will be used to choose the product or services.
   • A product or service is created in paper and positioned in the market. As a product or service available only in paper to be sold in the market through the existing links. At this juncture, the pricing of the product or the service needs to be finalized, linking the distribution system until the product or services reaches the end consumer.
   • Candidates who have developed such product or service could present the same as a project work to the Panel of Experts, including representatives from industry sector. If the presented product or service is found to have real potential, the candidates would be exposed to the next level of actual implementation of the project.

2. Go to any venture capital website (like sequoiacap.com) and prepare a proposal for funding from venture capital.

REFERENCE BOOKS


CAQC 305 Elective – I

IV SEMESTER

CAQC 401 - Elective – II

CAQC 402 - Project Work
SUGGESTED ELECTIVES
CAQE 01 - MARINE FOOD TECHNOLOGY

Unit I

Unit II
Packing – handling fresh fish, frozen packs, IQF, layered and shatter packs. Fishery by – products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer.

Unit III

Unit IV

Unit V
Novel product development, marketing and sea food export – MPEDA, marketing, government policies, export finance, economic importance. Novel products – nutrition promotion, consumer studies qualitative and quantitative research methods

REFERENCE BOOKS

UNIT I: Introduction to marine pharmacology

Terms and definitions. Medicinal compounds from marine flora and fauna - marine toxins – antiviral and antimicrobial agents.

UNIT II: Separation of bioactive compounds

Steps involved in Marine Pharmacology: extraction of crude drugs, screening, isolation, purification and structural characterization of bioactive compounds.

UNIT III: Drug formulation and designing


UNIT IV: Neutraceuticals


UNIT V: IPR

WTO-GATT & TRIPS. Different types of intellectual property rights (IPR) - patents - patent applications and rules governing patent - Selected examples of patent in biotechnology. Licensing and compulsory licensing.

REFERENCE BOOKS


CAQE 03. PLANT AND ANIMAL CELL CULTURE TECHNOLOGY

Unit I

Structure and organization of animal cell - Cell proliferation – Cell differentiation – Cell adhesion – Senescence – Cell transformation

Unit II

Cell culture media: Components, physicochemical properties – Serum: Components, advantages and disadvantages, serum free media – Use of Antibiotics – Primary cell culture: Initiation of cell culture, mechanical and enzymatic disaggregation – Cell lines: Development, characterization, maintenance – Cell separation

Unit III

Adherent & non adherent cell lines – Culture methods – Subculture – Cryopreservation – Contamination in animal cell culture – Quantification and cytotoxicity – Embryonic stem cells – cancer stem cells.

Unit IV

Plant tissue culture – Introduction, cellular totipotency, basic requirements for plant tissue culture laboratory, tissue culture media (constituents and preparations), types of culture – cell, protoplast, callus, suspension culture and its applications.

Unit V

Explant, surface sterilization, plant growth hormones, micropropagation (direct and indirect method), somatic hybridization, plant transformation technique using Agrobacterium tumefaciens, applications of plant tissue culture.

REFERENCE BOOKS

CAQE 04 - MICROBIAL TECHNOLOGY

Unit I
Isolation and screening of industrially important microbes; Large scale cultivation of industrial microbes; Strain improvement to improve yield of selected compounds e.g. antibiotics, enzymes or recombinant proteins.

Unit II
Basic principles of bioprocess as applied to selected microbes; Process optimization of selected products.

Unit III
Recombinant protein production in microbes; Commercial issues pertaining to the production of recombinant products from microbes; Downstream processing approaches; Industrial microbes as cloning hosts (Streptomyces/Yeast)

Unit IV
Environmental application of microbes; Ore leaching; Toxic waste removal; soil remediation.

Unit V
Microbial application in food and healthcare industries; Food processing and food preservation; Antibiotics and enzymes of pharmaceutical use.

REFERENCE BOOKS


Unit I

**Basic principle of Biochemical engineering**
Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

Unit II

**Concepts of basic mode of fermentation processes**
Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

Unit III

**Downstream processing**
Bioseparation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.

Unit IV

**Applications of enzymes in food processing**
Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucose oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

**Applications of Microbes in food process operations and production**
Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

Unit V

Enzyme kinetics; Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination
Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.
REFERENCE BOOKS


Unit I
Applications of statistics in biological sciences and genetics; Descriptive statistics; Mean; Variance; Standard deviation and coefficient of variation (CV); Comparison of two CVs; Skewness; Kurtosis

Unit II
Probability – axiomatic definition; Addition theorem; Conditional probability; Bayes theorem; Random variable; Mathematical expectation; Theoretical distributions – Binomial, Poisson, Normal, Standard normal and Exponential distributions; Sampling- parameter, statistic and standard error; Census sampling methods; Probability and non-probability sampling; Purposive sampling; Simple random sampling; Stratified sampling.

Unit III
Testing of hypothesis; Null and alternative hypothesis; Type I and type II errors; Level of significance; Large sample tests; Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test – testing of single mean; Testing of two sample means using independent t test, paired t test; Chi square test: Test for goodness of fit - association of attributes – testing linkage – segregation ratio.

Unit IV
Correlation – Pearson’s correlation coefficient and Spearman’s rank correlation; Partial and multiple correlation – regression analysis; Sample linear and non linear regression; Multiple regression.

Unit V
Analysis of variance – definition – assumptions – model; One way analysis of variance with equal and unequal replications; Two way analysis of variance; Non parametric tests – sign test – Mann Whitney ‘U’ test – Kruskal Wallis test.

REFERENCE BOOKS
CAQE 07- GENOMICS AND PROTEOMICS

Unit I
Introduction
Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

Unit II
Genome sequencing projects
Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs.

Unit III
Proteomics
Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

Unit IV
Pharmacogenetics
High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development

Unit V
Functional genomics and proteomics
Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics

REFERENCE BOOKS

**CAQE 08 - VACCINES**

**Unit I**
Innate Immunity; Activation of the Innate Immunity through TLR mediated signaling; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Protective immune response in bacterial; Viral and parasitic infections; Correlates of protection

**Unit II**
Vaccination and immune response; Appropriate and inappropriate immune response during infection: CD4+ and CD8+ memory T cells; Memory B cells; Generation and Maintenance of memory T and B cells; Dendritic cells in immune response

**Unit III**
Adjuvants in Vaccination; Induction of Th1 and Th2 responses by using appropriate adjuvants; Microbial, Liposomal and Microparticles as adjuvant; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and mucosal Immunity

**Unit IV**
Conventional vaccines; Bacterial vaccines; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine

**Unit V**
New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for specific targets; Tuberculosis Vaccine; Malaria Vaccine; HIV vaccine

**Reference books**


CAQE 09 - MOLECULAR VIROLOGY

Unit I
Economic losses due to important viruses; Types of plant viruses, DNA viruses, RNA viruses, satellite viruses, satellite RNA, satellite DNA, viroids, virusoids; Disease symptoms, local and systemic symptoms, necrosis, hypoplasia, hyperplasia; Vectors for virus transmission; Cell to cell and systemic movement of viruses, plasmodesmata and virus movement.

Unit II
Genome Organization of DNA viruses; Caulimovirus – eg. Cauliflower mosaic virus, Replication of CaMV, Badnavirus – Rice tungro virus (RTBV); Geminiviridae – Bean golden mosaic virus, β- DNAs of geminiviruses, rolling circle replication, Nanovirus – Banana bunchy top virus

Unit III
Genome Organization of positive-stranded RNA viruses – Potyviridae, Potato virusY (PVY), processing of polyprotein, Comoviridae, Citrus triesteza virus; Bromoviridae, Alfalfa mosaic virus; Tenuivirus, Tobacco mosaic virus, Replication of TMV, Tobacco rattle virus.

Unit IV
Genome Organization of negative-stranded RNA viruses; Rhabdoviridae, Sonchus yellow net virus; Bunyaviridae, Tomato spotted wilt virus; Tenuivirus, Rice stripe virus; Double-stranded RNA viruses, Reoviridae, Rice dwarf virus.

Unit V
Virus detection and diagnosis; Infectivity assays – Sap transmission, insect vector transmission, agroinfection (using Agrobacterium); Ultracentrifugation, electron microscopy, serological methods, immunelectrophoresis in gels, direct double-antibody sandwich method, Dot ELISA, Immunosorbtent electron microscopy (ISEM), Decoration technique, Polymerase chain reaction; DNA and oligonucleotide microarray; Gene silencing, PTGS & TGS, viral suppressors of gene silencing.

REFERENCE BOOKS