PSGCOLLEGE OF TECHNOLOGY, COIMBATORE - 641 004
(Autonomous college affiliated to Anna University, Chennai**)**

2020 CHOICE BASED CREDIT SYSTEM REGULATIONS OF TWO YEAR MSc DEGREE PROGRAMME

(For the batches of students admitted in 2020-2021 and subsequently)

NOTE: The regulations hereunder are subject to amendments as may be made by the Academic Council of the College from time to time. Any or all such amendments will be effective from such date and to such batches of students (including those already in the middle of the programme) as may be decided by the Academic Council.

1. a.**PRELIMINARY DEFINITIONS AND NOMENCLATURE**

In the following Regulations, unless the context otherwise requires

i. **"Programme"** means Degree Programme, that is **MSc Degree Programme**

ii. **"Branch"** means specialization or discipline of **MSc Degree Programme,** like **Applied Mathematics.**

iii. **"Course"** means a theory or laboratory course that is normally studied in a semester.

iv. **"University"** means **Anna University, Chennai.**

b. **CONDITIONS FOR ADMISSION**

i. Students for admission to the first semester of the M.Sc. degree examination of Anna University, Chennai will be required to satisfy the eligibility qualification for admission as given in section 3 infra or any other examination of any recognized University or authority accepted by Anna University, Chennai as equivalent thereto. The students shall also be required to satisfy all other conditions of admission thereto prescribed by the University and Government of TamilNadu.

2. **DURATION OF THE PROGRAMME**

i. **Minimum Duration:** The programme leading to the Degree of Master of Science (MSc) of the University will extend over a period of two academic years with two semester per academic year. Each semester shall normally consist of 90 working days including examination days.

Ii **Maximum Duration:** The student shall complete the programme in 2 years(4 semesters),but in any case not more than 4 years (8 semesters)these durations are to be reckoned from the commencement of the semester to which the student was first admitted to the programme.

3. QUALIFICATIONS FOR ADMISSION

The eligible qualifications for admission to MSc Applied Mathematics degree programme are listed below:

Department	MSc Degree Programme offered	Full-time (FT)/ Part-time (PT)	Eligible Qualification for Admission
Applied Mathematics and Computational Sciences	Applied Mathematics	FT	a)B.Sc. (Mathematics / Mathematics with Computer Applications) (or) b) B.Sc. (Applied Science).

4. STRUCTURE OF THE PROGRAMME

i. The course work of the odd semesters will normally be conducted only in odd semesters and that of the even semesters only in even semesters

ii. **Curriculum :** The curriculum includes courses of study and detailed syllabi. The courses of study include fifteen theory courses, three professional electives, six laboratory courses, Mini-Project and Seminar and Project Work as given in section 13 infra. **The minimum number of credits to be earned for the courses under the category Professional Elective is 12.**The Students shall opt electives from the list of electives corresponding to his/ her programme. The hours / week listed in section 13 infra for each of the courses refer to periods / week

Every student will normally undergo the courses of his/ her programme given in section 13 infra in various semesters as shown below.

	Number of Core Theory Courses	Number of Laboratory Courses	Number of Professional Electives
Semester 1	6	2	0
Semester 2	5	3	1
Semester 3	4	1	2
	Mini Project &Seminar		
Semester 4	Project Work		

ii. **Project Work:** Every student shall undertake the Mini-Project Work & Seminar during the semester vacation of second semester and evaluated during third semester and the Project Work during the fourth semester The Project Work shall be undertaken in an Industrial / Research Organization or in the College in consultation with the faculty guide and the Head of the Department (HoD). In case of Project Work at Industry / Research organization, the same shall be jointly supervised by a faculty guide and an expert from the organization. A student shall register for Mini Project & Seminar in third semester and Project Work in the fourth semester.

iv. **Online courses:** Students can register and earn credits for online courses approved by department committee consisting of HoD, Programme Coordinator and subject experts. Students who complete online courses successfully to a maximum of 4 credits may obtain exemption from studying one Professional Elective. The list of online courses is to be approved by Chairman Academic Council on the recommendation of HoD at the beginning of the semester if necessary, subject to ratification in the subsequent Academic Council Meeting. The Committee will monitor the progress of the student and recommend the grade or evaluate the candidate in 100% Continuous Assessment (CA) pattern, if necessary. A student can do the online courses from second to third semester.

v.**Course Enrollment and Registration**

a) Each student, on admission shall be assigned to a Tutor who shall advise and counsel the student about the details of the academic programme and the choice of courses considering the student's academic background and career objectives.

b) Each student on admission shall register for all the courses prescribed in the curriculum in the student's first semester of study.

c) From second semester onwards, a student has the option to drop a maximum of two theory courses except professional core courses in a semester and a student has the option to study additionally one theory course which shall be from professional electives. The maximum number of credits the student can register in a particular semester cannot exceed 30 credits including the redo courses.

d) A student shall register for the dropped course(s) in the next given opportunity and earn attendance to become eligible to appear for the end semester examination.

e) The courses to be offered in a semester for the students who need to reappear(as per 5 (iii) infra) or having attendance shortage etc., will be decided by HoD..

f) After registering for a course, a student shall attend the classes, satisfy the attendance requirements, earn Continuous Assessment Marks and appear for the end semester examinations.

The enrollment for all the courses of the Semester II will commence ten working days prior to the last working day of Semester I. The student shall confirm the enrollment by registering for the courses within the first five working days after the commencement of the Semester II.

The enrollment for the courses of the Semesters III and IV will commence ten working days prior to the last working day of the preceding semester. The student shall enroll for the courses with the guidance of the Tutor. If the student wishes, the student may drop or add courses subject to eligibility within five working days after the commencement of the concerned semester and complete the registration process duly authorized by the Tutor.

vi **Credit assignment:** Each course is assigned certain number of credits based on the following:

Contact Period per week	Credits
1 Lecture Period	1
2 Tutorial Periods	1
2 Practical Periods(Laboratory / Project Work/ etc.)	1

The contact periods per week for Tutorials and Practicals can only be in multiple of 2. The exact number of credits assigned to the different courses is shown in section 13 infra.

Vii **Minimum Credits:** For the award of the degree, the student shall earn the minimum number of credits of 85 by passing the prescribed courses of study as shown in section 13 infra.

viii **Medium of Instruction:** The medium of instruction, examinations, project report etc. shall be in English.

5. REQUIREMENTS OF ATTENDANCE AND PROGRESS

i. A student will be qualified to appear for end semester examinations in a particular course of a semester only if

a) he / she has satisfied the attendance requirements as per the norms given below:

- Shall secure not less than 75% attendance in that course take into account the number of periods required for that course as specified in the curriculum.
- If a student secures attendance 65% or more but less than 75% in any course in the current semester due to medical reasons (hospitalization / accident / specific illness) or due to participation in the College / University / State / National / International level sports events with prior permission from the Chairman, Sports Board and Head of the Department concerned, the student shall be given exemption from the prescribed attendance requirement and the student shall be permitted to appear for the end semester examination of that course.

b) his / her progress has been satisfactory and

c) his / her conduct has been satisfactory.

ii. A student shall normally be permitted to appear for end semester examination of the course if the student has satisfied the attendance requirements and has registered for examination in those courses of that semester by paying the prescribed fee.

iii. a. Students who do not satisfy clause 5(i) supra will not be permitted to appear for the end semester examination / evaluation of that course. The student has to register and redo that course in a subsequent semester when it is offered next, earn necessary attendance and CA mark and appear for end semester examinations.

b. If the total number of "Redo" courses at the end of any semester is more than two, the student will not be eligible to register for the next immediate and further semester courses.

iv) A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear in the same course for improvement of letter grades / marks.

6. DISCIPLINE

i Every student is required to observe discipline and decorous behavior both inside and outside the college not indulge in any activity which will tend to bring down the prestige of the college. The Head of the institution shall constitute a disciplinary committee to enquire into acts of indiscipline and notify the punishment.

ii If a student indulges in malpractice in any of the examination, he/she shall be liable for punitive action as decided by the Board of Examiners

7. PROCEDURE FOR REJOINING THE PROGRAMME

A student who desires to rejoin the programme after a period of discontinuance or who upon his/her own request is permitted by the authorities to repeat the study of any semester, may join the semester which he/she is eligible or permitted to join, only at the time of its normal commencement for a regular batch of students and after obtaining the approval from the University and Commissioner of Technical education. No student will however be enrolled in more than one semester at any time.

8. ASSESSMENT AND PASSING REQUIREMENTS

i. **Assessment:** The assessment will comprise of Final Examination (FE) and Continuous Assessment (CA), carrying marks as specified in the scheme in section 13 infra. The CA marks will be awarded on assessing the student continuously during the semester as per section 8(x) infra. The assessment for theory courses with CA + FE components will be done by absolute grading system. However, for the purpose of reporting the performance of a student, letter grades and grade points will be awarded as per grading norms stipulated in section 8(vi) infra.

ii. **Final Examinations:** Final examinations will normally be conducted during October / November and during March / April of each year. Supplementary examinations may be conducted at such times as may be decided by the college.

iii. **Mini-Project& Seminar:** Every student shall submit a report on Mini-Project Work on dates announced by the department through the faculty guide to the HoD. If a student fails to submit the report on Mini-Project Work on or before the specified date, he/she is deemed to have failed in it.

The student shall also present seminars about the progress of the Mini-Project Work during the appropriate semester. The seminars shall be presented before a review committee constituted by the HoD.

The Mini-Project Work will be evaluated based on the seminars, report and a viva-voce examination. The viva-voce examination will be carried out by a team of faculty appointed by the HoD and the internal examiner.

A student who fails in Mini-Project Work & Seminar shall register for redoing the same at the beginning of a subsequent semester. However, the student will be allowed to enroll for Project Work along with Mini-Project Work during the beginning of the subsequent semester for satisfactory completion of both the courses.

iv. **Project Work :** Every student shall submit reports on Project Work on dates announced by the college / department through the faculty guide to the HoD. If a student fails to submit the report on Project Work on or before the specified date, he/she is deemed to have failed in it.

The student shall give a presentation about the progress of the Project Work during the fourth semester to a review committee constituted by the HoD.

The Project Work will be evaluated based on the presentations, report and a viva-voce examination. The viva-voce examination will be carried out by a team consisting of an internal examiner, usually the supervisor, and an external examiner, appointed by the Principal. The continuous assessment marks of Project Work shall not be carried over to the next appearance, if the student had failed in the same.

A student who failed Project Work will have to redo and complete it within stipulated period.

v. **Laboratory Courses:** Every laboratory course shall be evaluated based on conduct of experiments/exercises/mini projects/development of software packages and reports

vi. **Letter Grade and Grade Point:** Based on students performance, a letter grade and grade point will be awarded as given below for each course at the end of each semester by following absolute grading system.

a. Absolute Grading System

In absolute grading system, the letter grade and grade points are awarded to each student based on the percentage of marks secured by the student in all as detailed below.

Absolute Grade Point Assignment

Range of percentage of total marks	Letter grade	Grade Point g
90 to 100	O	10
80 to 89	A+	9
70 to 79	A	8
60 to 69	B+	7
50 to 59	B	6
0 to 49 or less than 50% in the final examination	RA	0
Withdrawal from examination	W	0
Shortage of Attendance	SA	0

The grades RA and SA will not figure in the grade sheet.

b. For online courses the following grading pattern is applicable in case of credit transfer and CGPA calculations.

Range of percentage of total marks	Letter grade	Grade Point g
90 to 100	O	10
76 to 89	A+	9
60 to 75	A	8
50 to 59	B+	7
40 to 49	B	6

vii. **Cumulative Grade Point Average:** After the completion of the programme, the cumulative Grade Point Average (CGPA) from the first semester to final semester is calculated using the formula.

$$\text{CGPA} = \frac{\sum g_i * C_i}{\sum C_i}$$

where g_i is the Grade point secured corresponding to the courseI and C_i is the Credit rating of the course i

viii. Credit transfer for equivalent courses will be approved for students who study one or two semesters in approved foreign university**.**

ix. **Passing a course**

a. A student shall be deemed to have passed a theory course with CA+FE components, if

i. he/she secures at least 50% in the final examination and

ii. the total marks (CA +FE) secured by the student is at least 50%.

A student is deemed to have passed in any course carrying only continuous assessment marks (like Laboratory Course, Industry Visit and Lecture, Cluster Visit and Craft Documentation etc.) if the total mark secured by him/her is at least 50%.

A student is deemed to have passed in Project work if he/she secures at least 50% in the final viva voce examination and the total mark secured by him/her is at least 50%.

b. A student who after having earned necessary attendance is absent/has failed in any theory course of the end semester examination with CA and FE marks is permitted either to retain the CA marks already earned in that course and appear for supplementary examination immediately/subsequently and in such case, he/she will retain the already earned CA marks for this attempt only and thereafter he/she will be solely assessed by final examination carrying the entire marks of the course or to re-earn the CA marks only once in that course immediately/subsequently and appear for the end semester examinations and thereafter he/she will be solely assessed by final examination carrying the entire marks of the course.

c. A student who after having earned necessary attendance, is absent for the end semester examination or has failed in any course carrying only CA marks (like Lab, Project work etc.) will register for the supplementary examination immediately at the beginning of the next semester and be solely assessed in the final examination carrying the entire marks of that course.

d. A student who has earned necessary attendance in Mini Project & Seminar but does not submit the project report on or before the date specified by the college / department, he/she shall be deemed to have failed in it and awarded grade RA and will have to register for the same at the beginning of the subsequent semester. The

student has to redo the project work under the supervision of a faculty assigned by the HOD during the fourth semester, submit the project report at the end of fourth semester.

e. A student who has earned necessary attendance in Mini-Project &Seminar but whose project report is not accepted for reasons of incompleteness or other serious deficiencies will be treated as 'absent' and will have to register for the same at the beginning of the subsequent semester. The student has to redo the project work under the supervision of a faculty assigned by the HOD during fourth semester, submit the project report at the end of the fourth semester.

f. A student who has earned necessary attendance in Project Work but does not submit the project report on or before the date specified by the college / department, he/she shall be deemed to have failed in the Project work and awarded grade RA and will have to register for the same at the beginning of the subsequent semester, redo and submit the project report at the end of that semester and appear for the final examination by earning the CA mark afresh.

g. A student who has earned necessary attendance in Project Work but whose project report is not accepted for reasons of incompleteness or other serious deficiencies will be treated as 'absent' and will have to register for the same at the beginning of the subsequent semester, redo and submit the project report at the end of that semester and appear for the final examination by earning the CA mark afresh..

h. A student who has submitted the report of Project Work , but could not appear for the final examination on the scheduled date, shall be deemed to have failed in Project work and awarded grade RA.

i. If a student is absent or has failed in an elective course, he/she may register for the same course or any other elective course in the subsequent semester.

j. A student who is not eligible to write the End Semester Examination in any course due to lack of attendance, will be awarded grade SA and the student has to register for that course again, when offered next, attend the classes and fulfill the attendance requirements as per section 5 supra. If the course, in which the student has lack of attendance, is a Professional Elective, the student may register for the same or any other Professional Elective in the subsequent semesters.

k. A student after registering for a course may withdraw his / her registration between first &second CA test on valid reasons.

l. Out of the required three Professional Electives to be studied, students have to study compulsorily a minimum of two Professional Electives from the list of Professional Electives prescribed in their scheme of study. They can study the remaining one Professional Elective either from the list of electives prescribed in the scheme or as online courses/ special courses by obtaining equivalence.

   For students who complete more than three Professional Electives, the best two grades obtained among the Professional Electives studied under the scheme and the best one grade among all the remaining courses will be considered for the calculation of CGPA, though all the grades obtained will appear in the grade sheet.

m. A student with arrears after completing the prescribed minimum period of 2 years of continuous study, can also opt to register for the failed courses as and when offered.

n. A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear in the same course for improvement of letter grade / marks.

o. A student who is absent in the end semester examination of a course after registering for the same will be considered to have appeared and failed in that examination and awarded grade RA.

x. **Scheme of Evaluation**

a. Theory Courses (CA : 50% + FE : 50%) (all semesters) Total: 100 Marks

- **CA Distribution:**

(i) Assignment Presentation	8 Marks
(ii) Mini Project / Tutorials (Minimum 2)	12 Marks
(iii) Internal Tests:(Average of two tests)	30 Marks
• Test I 30 Marks	
• Test II 30 Marks	

- **Final Exam (FE**) 50 Marks

b. Laboratory Courses (CA :100%) (all Semesters) Total:100 Marks

- **CA Distribution:**

(i) Lab Test I	25 Marks
(ii) Lab Test II	25 Marks
(iii) Final Lab examination	30 Marks
(iv) Package / Viva-voce	20 Marks

c. Project Work (CA : 50% + FE : 50%) Total: 100 Marks

- **CA Distribution:** 50 Marks
  - (i) Review 1$ 25 Marks
  - (ii) Review 2# 25 Marks
- **Final Examination (FE)** 50 Marks
  - External 25 Marks
    - Thesis Evaluation 10 Marks
    - Presentation & Viva Voce 15 Marks
  - Internal 25 Marks
    - Thesis Evaluation 10 Marks
    - Presentation & Viva Voce 15 Marks

$- For Project Work first review will be carried out in the college. The review committee comprise of the Programme Coordinator / Tutor, two faculty of the department nominated by the HoD and the respective project guide.

#- Second review of Project Work will be carried out at the industry / Research Institute. The review committee shall include one faculty from the department and one mentor from the industry/ Research Institute.

d. <u>Mini Project & Seminar (CA : 100%)</u> **Total: 100 Marks**

- **CA Distribution:**

(i) Review - I 25Marks
- Guide 15 Marks
- Committee$ 10 Marks

(ii) Review – II 25 Marks
- Guide 15 Marks
- Committee$ 10 Marks

(iii) Final Review 50 Marks
- Guide 25 Marks
- Committee$ 25 Marks

$ -In respect of Mini project & Seminar and Project Work carried out and reviewed in the departments, the reviewing committee shall comprise of the Head of the Department/Project Coordinator, two faculty of the department nominated by the HoD and the respective project guide(s).

9. QUALIFICATION FOR THE AWARD OF DEGREE

A student will be declared to have qualified for the award of the M.Sc. degree provided

i. the student has successfully completed the course requirements and has passed all the prescribed courses of study of the respective programme listed in section 13infra within the duration specified in section 2(ii) supra and earned the total number of credits as specified in the curriculum of the respective programme of study. However, if the student wishes, he/she may be permitted to earn more than the total number of credits prescribed in the curriculum of his/her programme.

ii. no disciplinary action is pending against the student.

10. CLASSIFICATION OF DEGREE

A) First Class with Distinction

A student who satisfies the following conditions shall be declared to have passed in First class with Distinction.

- Should have passed the end semester examination in all the courses of all the four semesters in his/her First appearance within three years, which includes one year of authorized break of study (if availed) or withdrawal from examination (vide section 11 infra).
- Should have secured a CGPA of not less than 8.50.
- Should not have been disqualified from writing end semester examination due to lack of attendance in any of the courses.

B) First Class

A student who satisfies the following conditions shall be declared to have passed in First Class**.**

- Should have passed the end semester examination in all the courses of all four semesters within three years**,** which includes one year of authorized break of study (if availed) or not qualified for writing the end semester examination due to lack of attendance (if applicable).
- Should have secured a CGPA of not less than 7

C) Second Class

All other students (not covered in (A) and (B)) who qualify for the award of the degree shall be declared to have passed in Second class.

D) Rank

A student who has passed the examination in first class with distinction or first class with no history of reappearance is eligible for ranking. Those who have availed the provision of break of study / withdrawal will not be eligible for ranking.

11. WITHDRAWAL FROM EXAMINATION

i) A student may, for valid reasons, be granted permission to withdraw from appearing for the examination in any course or courses of only one semester if there is no history of reappearance at the time of request for withdrawal. Prior permission for withdrawal from semester examinations is to be obtained from Principal. Also, only one application for withdrawal is permitted for that semester examination in which withdrawal is sought.

ii) Withdrawal application shall be valid only if the student is otherwise eligible to write the examination and if it is made prior to the commencement of the examination in that course or courses and also recommended by the HoD.

12. TEMPORARY BREAK OF STUDY

i) Students have the provision to apply to the Principal to take a break of the study at the beginning of a semester to re-do and to complete the reappearance courses in the previous semesters or on other valid reasons and can rejoin the programme in a semester which the student is eligible by getting Principals approval. Such students are permitted to rejoin the programme at the respective semester as and when it is offered subject to the approval of Commissioner of Technical Education and Anna University, Chennai, and shall be governed by rules and regulations in force at the time of rejoining.

ii) The duration specified for passing all the courses for the purpose of classification (vide sections 10 supra) shall be increased by the period of such break of study permitted.

iii) The total period for completion of the programme reckoned from the commencement of the semester to which the student was first admitted shall not exceed the maximum period specified in section2 (ii) supra irrespective of the period of break of study in order that he/she may be qualified for the award of the degree.

iv) If any student is detained for want of requisite attendance, progress and conduct, the period spent in that semester shall not be considered as permitted 'Break of Study' and section 12 (iii) Supra is not applicable for such cases.

13. COURSES OF STUDY AND SCHEME OF ASSESSMENT
M.Sc APPLIED MATHEMATICS

(2020 REGULATIONS)
(Minimum Number of Credits to be earned: 85)

Course Code	Course Title	Hours / Week			Credits	Prerequisites	Maximum Marks			CAT
		L	T	P			CA	FE	Total	
SEMESTER 1										
20SA11	Contemporary Algebra	4	0	0	4		50	50	100	PC
20SA12	Real Analysis	4	0	0	4		50	50	100	PC
20SA13	Differential Equations	3	0	0	3		50	50	100	PC
20SA14	Probability, Stochastic Processes and Statistics	3	2	0	4		50	50	100	PC
20SA 15	Discrete Mathematics	3	0	0	3		50	50	100	PC
20SA16	Problem solving and C Programming	3	0	0	3		50	50	100	PC
20SA17	Professional Communication	0	0	2	1		100	-	100	HS
20SA18	C- Programming Lab	0	0	4	2		100	-	100	PC
Total 28 Hrs		**20**	**2**	**6**	**24**		**500**	**300**	**800**	
SEMESTER 2										
20SA21	Topology and Functional Analysis	3	0	0	3	20SA11, 20SA12, 20SA15	50	50	100	PC
20SA22	Complex Analysis	3	0	0	3	20SA11	50	50	100	PC
20SA23	Object Oriented Programming	3	0	0	3	20SA16	50	50	100	PC
20SA24	Data Structures	4	0	0	4	20SA15	50	50	100	PC
20SA25	Data Base Management System	3	0	0	3	20SA15	50	50	100	PC
20SA__	Professional Elective- I	3	2	0	4		50	50	100	PE
20SA26	Object Computing Lab	0	0	4	2		100	-	100	PC
20SA27	Data Structures Lab	0	0	4	2		100	-	100	PC
20SA28	Data Base Management System Lab	0	0	2	1		100	-	100	PC
Total 31 Hrs		**19**	**2**	**10**	**25**		**600**	**300**	**900**	
SEMESTER 3										
20SA31	Applied Graph Theory	3	0	0	3	20SA15.	50	50	100	PC
20SA32	Optimization Techniques	3	0	0	3	20SA11.	50	50	100	PC
20SA33	Number Theory and Cryptography	3	0	0	3	20SA11	50	50	100	PC
20SA34	Machine Learning	3	2	0	4	20SA11,20SA14, 20SA15	50	50	100	PC
20SA__	Professional Elective-II	3	2	0	4		50	50	100	PC
20SA__	Professional Elective III	3	2	0	4		50	50	100	PE
20SA35	Scientific Computing Lab	0	0	2	1	20SA11, 20SA13	100	-	100	PC
20SA36	Mini- Project & Seminar	-	-	4	2		100	-	100	EEC
Total 30Hrs		**18**	**6**	**6**	**24**		**500**	**300**	**800**	
SEMESTER 4										
20SA40	Project Work	-	-	**24**	12		50	50	100	EEC
Total 24 Hrs		-	-	**24**	**12**		**50**	**50**	**100**	

PROFESSIONAL ELECTIVE THEORY COURSES (Three to be opted)										
Course Code	Course Title	Hours / Week			Credits	Prerequisites	Maximum Marks			CAT
		L	T	P			CA	FE	Total	
20SA61	Algebraic Topology	3	2	0	4	20SA11,20SA12, 20SA21	50	50	100	PE
20SA62	Artificial Intelligence	3	2	0	4	20SA14,20SA15, 20SA24	50	50	100	PE
20SA63	Big Data and Modern Database Systems	3	2	0	4	20SA24,20SA25	50	50	100	PE
20SA64	Calculus of Variations and Transforms	3	2	0	4	20SA12, 20SA13	50	50	100	PE
20SA65	Classical Mechanics	3	2	0	4	20SA12, 20SA13	50	50	100	PE
20SA66	Computational Finance	3	2	0	4	20SA14,20SA15	50	50	100	PE
20SA67	Data Mining	3	2	0	4	20SA14	50	50	100	PE
20SA68	Design and Analysis of Algorithms	3	2	0	4	20SA15, 20SA24	50	50	100	PE
20SA69	Digital Image Processing and Computer vision	3	2	0	4	20SA24, 20SA64	50	50	100	PE
20SA70	Epidemic Models	3	2	0	4	20SA13,20SA14	50	50	100	PE
20SA71	Game Theory	3	2	0	4	20SA14,20SA15	50	50	100	PE
20SA72	Geometry of Locally Finite Spaces	3	2	0	4	20SA11,20SA12, 20SA21	50	50	100	PE
20SA73	Information Retrieval and Web Search	3	2	0	4	20SA24 ,20SA25	50	50	100	PE
20SA74	Mathematical Modeling	3	2	0	4	20SA14,20SA15	50	50	100	PE
20SA75	Mobile Application and Development	3	2	0	4	20SA23	50	50	100	PE
20SA76	Operating Systems	3	2	0	4	20SA16,20SA24	50	50	100	PE
20SA77	Predictive Analytics	3	2	0	4	20SA14	50	50	100	PE
20SA78	Statistical Learning	3	2	0	4	20SA12,20SA14, 20SA21	50	50	100	PE
20SA79	Stochastic Differential Equations	3	2	0	4	20SA13,20SA14	50	50	100	PE
20SA80	Topological Data Analysis	3	2	0	4	20SA11, 20SA12, 20SA21	50	50	100	PE

L- Lecture, T- Tutorial, P- Practical
CAT – Category; FC – Foundation Course; PC – Professional Core; PE - Professional Elective EEC – Employability Enhancement Course; HS – Humanities and Social Sciences
L-Lecture, T- Tutorial, P- Practical

SEMESTER I

20SA11 CONTEMPORARY ALGEBRA

4 0 0 4

GROUPS: Groups- Subgroups- Normal subgroups - Factor group - Cayley's theorem – Sylow's theorem. (10)

RINGS: Definition and Properties – Subrings, Ring of Quaternions, Integral domain - Homomorphism – Ideals and Quotient Rings – Euclidean ring - Unique factorization theorem, Domain of Gaussian Integers. Polynomials Rings – Properties, Division - Algorithm, Factorization of Polynomials – Primitive polynomials. (14)

FIELDS: Definition – subfields - Finite fields – structure of Finite field. (6)

VECTOR SPACES: Linear spaces, subspaces- Linear independence, basis, dimension - Dual spaces - Inner product spaces. (12)

LINEAR TRANSFORMATIONS: Definition and examples, null Space and the range space, rank-nullity-dimension theorem. Isomorphism between vector Spaces, matrix representation of a linear transformation, matrix for the composition and the Inverse. Similarity transformation, Linear functional. (12)

EIGENVALUES AND EIGEN VECTORS : Eigen values, eigenvectors, characteristic polynomial, Cayley-Hamilto*n* theorem, diagonalization. (6)

Total L : 60

TEXT BOOKS:
1. Herstein I N., 'Topics in Algebra', Wiley, 2017.
2. Stephen H. Friedberg, 'Linear Algebra', Prentice Hall, 2004.

REFERENCES:
1. Kenneth Hoffman, 'Linear Algebra', Prentice Hall, 2001.
2. Gilbert Strang, 'Linear Algebra and Its Applications', Thomson Learning, 2012.

20SA12 REAL ANALYSIS

4 0 0 4

METRIC SPACES: Definition and examples, compact sets, Heine-Borel theorem. continuous functions, uniform continuous functions. differentiation- mean value theorem, Taylor's theorem. (14)

THE RIEMANN STIELTJES INTEGRAL: Riemann Integral - definition and existence of integral, properties of the integral. Riemann Stieltjes Integrals, integration and differentiation. (12)

SEQUENCES AND SERIES OF FUNCTIONS: Uniform convergence, uniform convergence and continuity, differentiation and integration ,Equi-continuous families of functions. (12)

LEBESGUE MEASURE: Introduction, Lebesgue outer measure, σ- algebra of Lebesgue measurable sets, outer and inner approximations, countable additivity , continuity , Borel-Cantelli Lemma. Lebesgue measurable functions. (12)

LEBESGUE INTEGRATION; The Lebesgue integral -bounded measurable functions over a set of finite measure , measurable and non-negative functions, The general Lebesgue Integral (10)

Total L :60

TEXT BOOKS:
1. Walter Rudin, 'Principles of Mathematical Analysis', McGraw Hill, 2019.
2. Royden HL, Fitzpatrick, 'Real Analysis', Pearson, 2015.

REFERENCES:
1. Donald L.Chon 'Measure Theory', Birkhauser, 2013.
2. RoberrtC.Bartle, Donald R.Sherbert,' Introduction to Real Analysis', John Wiley, 2014.

20SA13 DIFFERENTIAL EQUATIONS

3 0 0 3

ORDINARY DIFFERENTIAL EQUATIONS: Introduction – Existence and uniqueness of initial value problems for first order ODEs – Homogeneous and non-homogeneous linear ODEs - Equations with constant and variable coefficients – Variation of parameters – Singular solutions – Reduction of order – Sturm-Liouville problems - Greens' function. (10)

SYSTEM OF ORDINARY DIFFERENTIAL EQUATIONS: System of first order ODEs – Fundamental matrix – Non-homogeneous linear systems – Linear system with constant coefficients – Picard's theorem – Continuation and dependence on initial conditions – Existence and uniqueness of solutions. (9)

PARTIAL DIFFERENTIAL EQUATIONS: Introduction – Classification of integrals – Linear equations of the first order - Integral surface passing through the given curve – Pfaffian differential equations – Compatible systems – Charpit's method – Jacobi's method. (9)

APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS: Fourier series - Classification of second order PDEs – Canonical form – Method of separation of variables – One dimensional wave equation – D'Alembert's solution – Vibrations of a finite string – Heat conduction problem – Finite rod case (9)

Nonlinear Systems: Autonomous Systems - Phase plane and its phenomena – Stability for linear systems – Lyapunov's direct method – Simple critical points of nonlinear systems. (8)

Total L : 45

TEXT BOOKS:

1. Earl. A. Coddington, 'An Introduction to Ordinary Differential Equations', Prentice Hall, 1992.
2. I.N. Sneddon, 'Elements of Partial Differential Equations', Tata McGraw-Hill, 2006.
3. S.G.Deo, V.Ragavendra, RasmitaKar, V.Lakshmikantham, 'Text book of Ordinary Differential Equations', Mc-Graw Hill, 2015.

REFERENCES:

1. G.F. Simmons, 'Differential Equations with Applications and Historical Notes', Tata McGraw-Hill, 2017.
2. William E. Boyce, Richard C. DiPrima, 'Elementary Differential Equations and Boundary Value Problems', Wiley, 2009.
3. Lawrence Perko, 'Differential Equations and Dynamical Systems', Springer, 2006.

20SA14 PROBABILITY, STOCHASTIC PROCESSES AND STATISTICS

3 2 0 4

SAMPLE SPACE AND PROBABILITY: Sets, probability models, conditional probability, total probability theorem, Bayes' rule, independence, counting. (6 + 4)

RANDOM VARIABLES: Discrete and Continuous random variables - Probability mass function and density function, distribution function. Expectation and variance. Discrete distributions: Binomial, Poisson and Geometric. Continuous Distributions: Uniform, Normal, Exponential and Weibull. Joint probability distributions, marginal and conditional distributions, Independent random variables, sums of independent random variables, Conditional expectation and variance. (10 + 7)

LIMIT THEOREMS: Markov and Chebyshev inequalities, Law of Large Numbers, Convergence in probability, Central Limit Theorem. (7 + 4)

STOCHASTIC PROCESSES: Bernoulli and Poisson process, Markov chains- Discrete- Time Markov chain, Classification of states, steady-state behavior, absorption probability and expected time to absorption, period, Continuous-Time Markov chains-Birth and death process. (10 + 7)

BAYESIAN STATISTICAL INFERENCE: Statistical inference, prior and posterior distributions, conjugate prior distributions, Point estimation, maximum likelihood estimators. Testing of Hypotheses-problems of testing hypotheses, testing simple hypotheses, uniformly most powerful tests. Two-sided test, t - test, comparing means of two normal distributions, F-distribution, Bayes test procedure. Linear statistical models - Method of least squares, regression, statistical inference in simple linear regression, Bayesian inference in simple linear regression (12 + 8)

Total L : 45 + T:30 = 75

TEXT BOOKS:

1. Dimitri P. Bertsekas and John N,Tsitsiklis, 'Introduction to Probability', Athena Scientific, 2008.
2. Morris H. DeGroot, Mark J. Schervish, 'Probability and Statistics' Pearson Education ,2018.
3. SaeedGhahramani, ' Fundamentals of probability with Stochastic Processes', Pearson Education, 2019.

REFERENCES:

1. Peter Olofsson and Mikael Andersson, 'Probability, Statistics and Stochastic processes' John Wiley,2012.
2. Robert V. Hogg, Elliot A. Tanis, Dale L. Zimmerman, ' Probability and Statistical Inference', Pearson,2019.

20SA15 DISCRETE MATHEMATICS

3 0 0 3

MATHEMATICAL LOGIC: Proposition - Logical operators - Truth tables – Laws of Logic – Equivalences – Rules of inference - Validity of arguments – Consistency of specifications – Propositional Calculus – Quantifiers and universe of discourse.(8)

RELATIONS AND FUNCTIONS: Definition and properties of binary relations – Representing relations – Closures of relations – Composition of Relations – Equivalence relations – Partitions and covering of Sets – Partial Orderings – n-ary Relations and their applications. Functions-Injective, surjective, bijective functions, Composition, Identity and Inverse. (8)

LATTICES: Lattices as partially ordered set – Properties of Lattices– Lattices as algebraic system – Sublattices – Direct product and Homomorphism – Some special lattices. (10)

COMBINATORICS: Basics of counting – The Pigeonhole principle - Permutations and Combinations with and without repetition, Permutations with indistinguishable elements, distribution of objects - Generating permutations and combinations in lexicographic order. (8)

RECURRENCE RELATIONS: Recurrence Relation Models- Solutions of linear homogeneous recurrence relations with constant coefficients- solution of linear non-homogeneous recurrence relations by the method of characteristic roots - Divide and conquer recurrence relations. (11)

Total L : 45

TEXT BOOKS:

1. Kenneth H. Rosen, 'Discrete Mathematics and its Application', Mc-Graw Hill, 2012.
2. Judith L. Gersting, 'Mathematical Structures for Computer Science', W.H. Freeman and Company, 2014.
3. Tremblay J. P. and Manohar R., 'Discrete Mathematical structures with application to Computer Science', Tata Mc-Graw Hill, 2011.

REFERENCES:

1. Doerr Alan and Levasseur K., 'Applied Discrete Structures for Computer Science', Galgotia , 2002.
2. BenardKolman, Robert C. Busby and Sharan Ross, 'Discrete Mathematical Structures', Pearson Education, 2014.
3. Ralph P. Grimaldi, 'Discrete and Combinatorial Mathematics – An Applied Introduction', Addison Wesley, 2009.

20SA16 PROBLEM SOLVING AND C PROGRAMMING

3 0 0 3

PROBLEM SOLVING: Introduction to Problem Solving- Program development- Analyzing and Defining the Problem – Algorithm-Flow Chart - Programming languages-Types of programming languages- Program Development Environment. (4)

C LANGUAGE: Introduction to C Language - C Character Set - Identifiers and Keywords - Data Types – Literal Constants - Variables – l-value-r-value - Qualifiers – Modifiers - Operators and Expressions – Type conversions - Library Functions - Data Input and Output Functions – escape sequence characters – Formatted input and output. (4)

CONTROL STATEMENTS: Making Decisions : If Statement – If/else Statement - If/else if Statement – Nested if Statements – dangling else - Switch Multiple Selection Statement– Repetition : Repetition Essentials - While Loop – do-While Loop – For Loop – Nested Loops – Breaking out of a Loop Continue statement – goto Statement (5)

FUNCTIONS: Modular Programming – Function Prototypes - Defining and Calling Functions –Function Call Stack and Activation Records - Passing Arguments to Functions – Returning a value from a function- Recursion – Recursion vs. Iteration – Scope and lifetime of variables – Memory layout of a C program - Storage Classes - Auto - Static - Extern and Register Variables. (5)

ARRAYS: Defining Array –Array Initialization - Accessing array elements - Processing arrays - Arrays as function arguments - Multidimensional arrays – Memory address calculation of an array – Row major and column major order - String Handling,(5)

POINTERS: Pointer Variable Definitions and Initializations – Passing Arguments to Functions by address – Pointer Expressions and Pointer Arithmetic - Relationship between Pointers and Arrays - Pointers and multidimensional arrays – Constant Pointer – Pointer to Constant –NULL pointer- dangling pointers - Pointers to functions - passing functions to other functions – Introduction to Stack and Heap Memory - Dynamic Memory Allocation. (8)

STRUCTURES AND UNIONS: Structure Definitions – Initializing Structures – Accessing Structure Members - Processing a structure - typedef- Structures and pointers - Passing structures to functions – Self-Referential Structures- Bit fields - Unions – Enumeration Constants. (6)

FILES: Files and Streams - Operations on Files – Types of Files, Various Read and Write Functions for Sequential-Access and Random-Access Files -Command Line Arguments. (4)

PREPROCESSOR DIRECTIVES: #include Preprocessor Directive - #define Preprocessor Directive: Symbolic Constants - #define Preprocessor Directive : Macros - Conditional Compilation. (4)

Total L : 45

TEXT BOOKS:

1. Brian W. Kernighan and Dennis Ritchie, 'The C Programming Language',Pearson Education,2015.
2. R G Dromey, 'How to solve it by Computer', Pearson 2008.

REFERENCES:

1. Herbert Schildt, "C The Complete Reference", Mc-Graw Hill, 2017.
2. Gottfried B, 'Programming With C', Mc-Graw Hill, 2011.
3. Peter Prinz and Tony Crawford, 'C in a Nutshell', O'Reilly, 2016.

20SA17 PROFESSIONAL COMMUNICATIONS

0 0 2 1

Reading Compression : Reading for Critical Purposes (2)

Scientific Style : Clarity – Simplicity – Exactness – Brevity – Unity – Coherence-Objectivity. Formal and Informal Writing (4)

Presentation Skills. (2)

Introduction to Soft Skills. (2)

Interpersonal - Intrapersonal Communication (2)

Meetings . (2)

Professional Report Writing, (4)

Professional Values and Ethics – Case analysis. (4)

PRACTICALS

Short Speeches,Group Discussions, Meetings. (8)

Total P : 30

References:
1. Course materials prepared by the faculty, Department of English
2.Meenakshi Raman and Sangeeta Sharma, 'Technical Communication: Principles and Practice'. Oxford University Press, 2015.
3. Dhanavel S.P., 'English and Soft Skills', Orient Black Swan, 2010.
4.Murphy Herta.Hildelrandt, Herbert W and Thomas Jane P, "Effective Business Communication", Tata Mc.Graw – Hill 2008.
5 PriyadarshiPatnaik, "Group Discussion and Interview Skills", Indian Institute of Technology, Kharagpur, 2011.

20SA18 C PROGRAMMING LAB

0 0 4 2

1. Simple programs to understand the concepts of data types.

2. Familiarizing conditional, control and repetition statements.

3**.**Usage of single and double dimensional arrays including storage operations.

4.Implementation of functions, recursive functions.

5. Defining and handling structures, array of structures and union.

6.Implementation of pointers, operation on pointers and dynamic storage allocation.

7. Creating and processing data files.

TOTAL P : 60

SEMESTER II

20SA21 TOPOLOGY AND FUNCTIONAL ANALYSIS

3 0 0 3

Prerequisites:
20SA11 -Contemporary Algebra,
20SA12 - Real Analysis,
20SA15 – Discrete Mathematics.

TOPOLOGICAL SPACES AND CONTINUOUS FUNCTIONS: Topological spaces, basis for a topology, subspace topology, order topology, closed sets and limit points, Hausdroff spaces, product topology, metric topology-continuous functions. (10)

CONNECTEDNESS AND COMPACTNESS: Connected spaces, connected sub sets of the real line, local connectedness, compact spaces, locally compact spaces (7)

COUNTABILITY AND SEPARATION AXIOMS: Countability axioms. separation axioms, normal spaces, Urysohn's lemma, Tietze extension theorem, Uryshon's metrization theorem, Tychonoff theorem. (10)

BANACH SPACES: Definition and examples, continuous linear transformations. Hahn-Banach theorem, the natural imbedding of a normed space, the open mapping theorem, the closed graph theorem. (10)

HILBERT SPACES: Definition and simple properties, orthogonal complements, orthonormal sets- Bessel's inequality. (8)

Total L : 45

TEXT BOOKS:
1. James R Munkres, 'Topology - A First Course', Pearson, 2018.
2. George F Simmons, 'Introduction to Topology and Modern Analysis', Tata Mc-Graw Hill, 2017.

REFERENCES:
1.O.Ya.Viro,O.A.Ivanov,N.Yu.Netsvetaev,'Elementary Topology', AMS,2008.
2.Erwin Kreyszig, 'Introductory Function Analysis with Applications', John Wiley, 2007.
3. Limaye B.V. 'An Introduction to Functional Analysis', New age International, 2014.

20SA22 COMPLEX ANALYSIS

3 0 0 3

Prerequisites:
20SA12 - Real Analysis.

ANALYTIC FUNCTIONS AND FUNDAMENTAL THEOREMS: Analytic functions, harmonic conjugates, elementary functions, Mobius transformation, conformal mappings, Cauchy's theorem and Integral formula, Morera's Theorem, Cauchy's theorem for triangle, rectangle, Cauchy's theorem in a disk, Zeros of Analytic function. The index of a closed curve, counting of zeros. principles of analytic continuation. Liouville's theorem, fundamental theorem of algebra. (13)

SERIES: Series, uniform convergence, power series, radius of convergences, power series representation of Analytic function, Relation between Power series and Analytic function, Taylor's series, Laurent's series. (10)

RESIDUES AND POLES: Rational Functions, singularities, poles, classification of singularities, characterization of removable singularities, poles. behavior of an analytic functions at an essential singular point, conformal mapping, (8)

COMPLEX INTEGRATION : Entire and meromorphic functions, residue theorem, evaluation of definite integrals, argument principle, Rouche's Theorem, Schwartz lemma, Open mapping and Maximum modulus theorem and applications, convex functions, Hadmard's Three circle theorem. (14)

Total L : 45

TEXT BOOKS:
1. J. B. Conway, 'Functions of One Complex Variable', Narosa, 2007.
2. L.V. Ahlfors, 'Complex Analysis', Mc-Graw Hill, 2013.

REFERENCES:
1 .Churchill, R.V. and Brown, J.W., 'Complex Variables and Applications'Mc-Graw Hill, 2004.

20SA23 OBJECT ORIENTED PROGRAMMING

3 0 0 3

Prerequisites:
20SA16- Problem solving and C – Programming.

PRINCIPLES OF OBJECT ORIENTED PROGRAMMING: Procedure Oriented Programming - Object Oriented Programming Paradigm. (1)

FUNCTIONS IN C++: Function Prototyping - Call by Reference - Return by reference - Inline functions - Default, Const Arguments - Function - Overloading. **Classes and Objects** - Member functions - Nesting of Member functions - Private member functions - Memory allocation for Objects - Static data members - Static MemberFunctions - Arrays of Objects - Objects as Function Arguments - Friend Functions - Returning Objects - Const Member functions - Pointers to Members (6)

CONSTRUCTORS: Parameterized Constructors - Multiple Constructors in a Class - Constructors with Default Arguments –Dynamic Initialization of Objects - Copy and Dynamic Constructors – Destructors overloading. (3)

INHERITANCE AND POLYMORPHISM:: Defining Derived Classes – Types - Compile and Run Time Polymorphism - Virtual function –Overloading Unary and Binary Operators - Overloading Binary Operators using Friend functions – Operator Type conversion. (7)

TEMPLATES : Introduction to Templates, Generic Functions and Generic Classes. (2)

INTRODUCTION TO JAVA: Data Types - Declarations –Wrapper Classes - Arrays and Strings – Input/Output.- Java Classes andMethods - Constructors - Scope rules - this keyword. (6)

PACKAGES AND INTERFACES: Packages - Access protection - Importing packages – inheritance vs Interfaces - Defining and Implementing Interface - Applying Interface. (4)

EXCEPTION HANDLING: Fundamentals - Exception types - Uncaught Exception - Using Try and Catch - Multiple catch clauses - Nested Try statements - Throw - Throws - Java Built-in Exception – User defined Exceptions. (4)

MULTI THREADED PROGRAMMING: Java thread model - Priorities - Synchronization - Messaging - Thread class and runnable Interface - Main thread - Thread creation - Synchronization - Interthread Communication – Deadlock. (5)

I/O: I/O basics - Stream - Stream Classes - Predefined stream - Reading/Writing console Input. (3)

GUI: Applet fundamentals - GUI Components – Event Handling. (4)

Total L : 45

TEXT BOOKS:
1. Stanley B. Lippman, JoseeLajoie andBarbara E. Moo, 'The C++ Primer', Addison Wesley, 2013.
2. Herbert Schildt, 'JAVA - The Complete Reference', Tata Mc-Graw Hill, 2018.

REFERENCES:
1 Scott Meyers, 'More Effective C++', Addison Wesley, 2008.
2. BjarneStroustrup, 'The Design and Evolution of C++', Addison Wesley, 2005.
3. Harvey M. Deitel and Paul J. Deitel, 'JAVA: How to Program', Pearson Education, 2018.
4. Horstmann and Cornell, 'Core Java', Prentice Hall, 2012.

20SA24 DATA STRUCTURES

4 0 0 4

Prerequisites:
20SA15 –Discrete Mathematics

INTRODUCTION: Data structures - Abstract Data Type - Primitive data structures - Analysis of algorithms- Best, worst and average case time complexities – Asymptotic notations. (6)

ARRAYS: Operations - Implementation of one, two, three and multi dimensioned arrays – Sparse and dense matrices – Applications. (4)

STACKS: Primitive operations - sequential implementation - Applications: Subroutine handling - Recursion – Expression Processing. (4)

QUEUES: Primitive operations – circular queue- Priority Queues – Dequeues. (4)

LISTS: Primitive Operations - Singly linked lists, Doubly linked lists, Circular linked lists, Multiply linked lists - Applications: Addition of Polynomials; Multiply linked list : Sparse Matrix representation and Operations. – Linked Stacks - Linked queues - Linked Priority queues - Dynamic Storage Management. (8)

TREES: Terminologies – Binary tree: Properties - Sequential and linked representation - Common binary tree operations - Traversals - Expression trees - Infix, Postfix and Prefix expressions - Threaded trees - Heaps, Max heap, Min heap. (10)

DICTIONARY DATA STRUCTURES: Binary Search Trees-Search, Insertion, Deletion-Time Complexity. AVL Tree- Insertion-Rotation-Deletion-Complexity. Hash Tables-hash functions-collision handling techniques and resolution. (9)

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MULTIWAY SEARCH TREES: Indexed Sequential Access – m-way search trees – B-Tree – searching, insertion and deletion. (5)

GRAPHS: Introduction-representations -Adjacency matrix, packed adjacency list and linked adjacency list– Graph search methods-Breadth first and depth first traversals. (6)

SORTING AND SEARCHING: Insertion sort, selection sort, bubble sort, heap sort, count sort and radix sort - Linear Search, Binary Search-Time Complexity. (4)

Total L : 60

TEXT BOOKS:

1. SahniSartaj, 'Data Structures, 'Algorithms and Applications in C++', Silicon Press,2011.
2. Aaron M. Tanenbaum, Moshe J. Augenstein and YedidyahLangsam, 'Data structures using C and C++', Prentice Hall, 2016.
3. Michael T. Goodrich, Roberto Tamassia and David Mount, 'Data Structures and Algorithms in C++', John Wiley, 2011.

REFERENCES:

1. Alfred V. Aho, John EHopcraft, Jeffrey D. Ullman, 'Data structures and Algorithms', Pearson Education, 2009.
2. Mark Allen Weiss, 'Data Structures and Algorithm Analysis in C++', Addison-Wesley, 2014.
3. Nell Dale, Chip Weems, and Tim Richards, 'C++ Plus Data Structures', Jones and Bartlett Learning, 2017.
4. Robert L. Kruse and Clovis L. Tondo, 'Data Structures and Program Design in C', Pearson Education, 2013.

20SA25 DATABASE MANAGEMENT SYSTEM

3 0 0 3

Prerequisites:
20SA15 – Discrete Mathematics

BASIC CONCEPTS: Introduction to databases – Conventional file processing – Purpose of database system – Characteristics of database approach – Advantages of using DBMS – Database concept and architecture – Data Abstraction – Data Models – Instances and Schema – Data Independence – Schema Architecture – Components of a DBMS. (8)

DATA MODELING: Introduction – Data associations – Entities, attributes, relationships – Type role and structural constraints – Weak and Strong entity types – Design of Entity Relationship data models (ERD) – Generalization – Aggregation – Conversion of ERD into tables – Applications – Introduction to Network data model and Hierarchical data model. (6)

FILE ORGANIZATION: Storage device characteristics – Constituents of a file – Operations on file – Serial files – Sequential files – Index sequential files – Direct files – Primary and Secondary Key Retrieval – Types of indexes - Indexing using Tree Structures (6)

RELATIONAL MODEL: Introduction to Relational Data Model – Basic concepts – Enforcing Data Integrity constraints – Relational Algebra Operations – Extended Relational Algebra Operations. (6)

RELATIONAL DATABASE MANIPULATION: Introduction to Structured Query Language (SQL) – SQL Commands for defining Database, Constructing database, Manipulations on database – Basic data retrieval operations – Advanced Queries in SQL – Functions in SQL – Aggregation – Categorization – Updates in SQL – Views in SQL –— PL/SQL Basics – Procedures – Functions – Triggers. (5)

DATA BASE DESIGN THEORY: Data base design process – Relational Database Design – Relation Schema – Anomalies in a database – Functional dependencies – Axioms – Normal forms based on primary keys – Second Normal form, Third Normal form, Boyce – Codd Normal form – Examples – Multi-valued dependencies – Fourth Normal form – Reduction of an E-R schema to Tables – Practical database design tuning (8)

TRANSACTION PROCESSING AND CONCURRENCY CONTROL: Transactions, Locking techniques, Concurrent access, Deadlock handling. (3)

DATABASE SECURITY, INTEGRITY CONTROL: Security and Integrity threats – Defense mechanisms – Discretionary Access Control and Mandatory Access Control. (3)

Total L : 45

TEXT BOOKS:
1. RamezElmasri and NavatheShamkranth, 'Fundamentals of Database Systems', Pearson Education, 2016.
2. Silberschatz A, Korth H and Sudarshan S, 'Database System Concepts', Mc-Graw Hill, 2019.

REFERENCES:
1. Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom, 'Database Systems: The Complete Book', Pearson Education, 2011.
2. Raghu Ramakrishnan and Johannes Gehrke,'Database Management System', Mc-Graw Hill, 2014.

20SA27 OBJECT COMPUTING LAB

0 0 4 2

1. Arithmetic operations using array of objects and dynamic data members.

2.Creation of a class which keeps track of the member of its instances. Usage of static data member, constructor and
Destructor. to maintain updated information about active objects.

3, Usage of a function to perform the same operation on more than one data type.

4.Overloading the operators to do arithmetic operations on objects.

5. Acquisition of the features of an existing class and creation of a new class with added features in it.

6. Implementation of run time polymorphism.

7. Use and create packages and interfaces.

8. Implementation of exception handling.

9. Implementation of Multithreading.

10, Creation of an effective GUI that handles various events performed with the appropriate actions,

TOTAL P: 60

20SA28 DATASTRUCTURES LAB

0 0 4 2

1.Sparse and dense Matrix operations using arrays.

2. Library of string operations - representing strings using arrays.

3.Stack and Queue using array.

4. Linked Lists: Singly linked, Doubly linked and Circular lists

5. .Linked Stacks and Queues.

6. Conversion and Manipulation of Expressions.

7. Binary trees and Threaded trees.

8. Hash Table linear probing and chaining.

9. BST, AVL tree implementation

10. Graph Traversal

TOTAL P: 60

20SA29 DATABASE MANAGEMENT SYSTEM LAB

0 0 21

1.Working with DDL and DML for creation and manipulation of single, multiple tables, Report Generation.

2.Practicing DCL commands to control access privileges.

3**.** Working with TCL commands to manage transactions in databases.

4Working with PL/SQL- Triggers and stored procedures..

5. Developing Packages using databases.

TOTAL P: 30

SEMESTER III

20SA31 APPLIED GRAPH THEORY

3 0 0 3

Prerequisites:
20SA15 – Discrete Mathematics.

Basic Concepts: Graphs, digraphs, subgraphs, graph models, graph representations, degree sequence. Walk, trail, path, connected graph, distance, diameter, clique, independent set, vertex cover. Graph isomorphism, graph decomposition. Algorithms – time and space complexities. Depth-first and breadth-first search algorithms. (10)

Trees & Connectivity: Trees – characterizations, spanning tree - matrix tree theorem, Prim's and Kruskal's algorithms, Cayley's formula. Shortest path problem – Dijkstra's algorithm, Floyd's algorithm for all pair shortest path. Vertex and edge connectivity, relationship between vertex and edge connectivity, bounds for connectivity. Constructing reliable network- Harary's k-connected graphs. (10)

EULERIAN & HAMILTONIAN GRAPHS: Eulerian trails and tours. Optimal Chinese Postman Tour – Edmond's and Johnson algorithm, Eulerian trail – Fleury's algorithm, Hierholzer's Algorithm. Hamiltonian cycles – Ore's and Dirac's conditions. Gray codes, Traveling Salesman problem – Christofide's algorithm. Walecki's construction. . (8)

MATCHING &NETWORK FLOWS: Matching, Bipartite matching, Hall's theorem, Perfect matching, Tutte's 1-factor theorem, augmenting path algorithm, Edmonds's Blossom Algorithm, Gale–Shapley algorithm. Flows and cuts, maximum flow problem, Max-flow Min-cut Theorem, Ford-Fulkerson Algorithm. (9)

COLORING & PLANAR GRAPHS: Vertex-coloring – upper chromatic number, bounds using clique number, maximum degree, Welsh – Powell theorem. Sequential and largest degree first algorithms, applications to frequency assignment. Euler's formula, dual graph, Kuratowski's theorem, 4-color problem, Wagner's theorem. Planarity testing – Hopcraft-Tarjan algorithm (8)

Total L : 45

TEXT BOOKS:
1. Jonathan Gross and Jay Yellen, 'Graph Theory and its Applications', CRC Press, Boca Raton, 2019.
2. Bondy J.A. and Murty U.S.R., 'Graph Theory' Springer, 2013.

REFERENCES:
1. Douglas B West, 'Introduction to Graph Theory', Pearson, 2018.
2. Balakrishnan R and Ranganathan K, 'A Textbook of Graph Theory', Springer, 2012.
3. Thulasiraman K and Swamy M N S, 'Graphs: Theory and Algorithms', John Wiley, 2014.
4. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 'Introduction to Algorithms', MIT Press, 2009.

20SA32 OPTIMIZATION TECHNIQUES

3 0 0 3

Prerequisites:
20SA15 – Contemporary Algebra.

LINEAR PROGRAMMING: Linear programming modeling – Solution techniques – Graphical method, Simplex method, Big M method , Two Phase method - Special cases of Simplex method. (10)

DUALITY AND SENSITIVITY ANALYSIS: Sensitivity Analysis for Graphical method and general linear programming model- Dual Problem – Primal and Dual relationship – Economic Interpretation of duality – Dual Simplex method – Post Optimal Analysis (9)

NON-LINEAR PROGRAMMING: Elimination methods for one dimensional minimization problems – Unimodal function - Interval halving method, Fibonacci method, – Hooke and Jeeves pattern search method – Indirect search methods – Cauchy's steepest descent method, Fletcher-Reeves conjugate gradient method . (8)

DECISION MAKING: Decision making under certainty and uncertainty – decision making under risk (6)

DYNAMIC PROGRAMMING : Principle of optimality **-** Forward and Backward Recursion methods – Shortest route problem - Knapsack model – Work force size model (6)

FINANCIAL APPLICATIONS : Dynamic Programming approaches to solve Financial problems - Option Pricing using Binomial Lattice - Mortgage backed securities (6)

Total L : 45

TEXT BOOKS:
1. Hamdy A Taha, 'Operations Research :An Introduction', Pearson Education, 2017
2. Singiresu S Rao, 'Engineering Optimization Theory and Practice', John Wiley, 2014.

REFERENCES:
1. Hillier.F and Lieberman G J,'Introduction to Operations Research', Tata Mc-Graw Hill, 2012.
2. Cornuejols and RehaTutuncu, 'Optimization Methods in Finance', Cambridge University Press, 2007.

20SA33 NUMBER THEORY AND CRYPTOGRAPHY

3 0 0 3

Prerequisites:
20SA15 – Contemporary Algebra.

ARITHMETICAL FUNCTIONS: Divisibility-Division Algorithm, Euclidean Algorithm; Primes-Fundamental Theorem of Arithmetic: Arithmetic function-Euler totient function. (6)

CONGRUENCES: Introduction to Congruence - Definition, properties, Ring of integer modulo n, Prime field, Primitive roots, Irreducible polynomial, Chinese remainder Theorem, Euler, and Fermat Theorem, Legendre, Jacobi, and Quadratic Reciprocity. (6)

CRYPTOGRAPHIC PRIMITIVES: Definitions and Illustrations: Symmetric-Key Cryptography, Classical Ciphers, Stream Ciphers, Block Ciphers LFSRs, Modes of Operation, DES, AES - Attacks. (9)

PUBLIC-KEY CRYPTOGRAPHY: Principles of PKC, RSA Cryptosystem, PKC based on the Discrete Logarithm problem -ElGamal Cryptosystem and Elliptic Curve systems. (9)

HASH FUNCTIONS AND SIGNATURE SCHEMES: Hash functions based on Cryptosystems, Message Digest, The RSA signature scheme, The Digital Signature Algorithm. The ElGamal signature scheme. (8)

KEY DISTRIBUTION AND KEY AGREEMENT: Introduction, Key transport based on symmetric encryption - Kerberos. Key agreement based on symmetric techniques - Blom's Scheme, Key transport based on public key encryption-Needham –Schroeder protocol, Key agreement based on asymmetric techniques- Diffie-Hellman key agreement protocol, station- to- station protocol. (7)

Total L : 45

TEXT BOOKS:
1. Neal Koblitz, 'A course in Number Theory and Cryptography', Springer, 2012.
2. Richard A. Mollin, 'Introduction to Cryptography', Chapman & Hall CRC, 2007.
3. Douglas R Stinson, 'Cryptography Theory and Practice', CRC Press, 2006.

REFERENCES:
1. Alfred J, Menezes, Paul C, Van Oorschot and Scott A Vanstone, 'Hand Book of Applied Cryptography', CRC Press, 2010.
2. Josef Pieprzyk, Thomas Harjono and Jenifer Seberry, 'Fundamentals of Computer Security', Springer, 2010.
3. Behrouz. A. Forouzan, 'Introduction to Cryptography and Network Security', Tata Mc-Graw Hill, 2010.
4 .Gustavus J. Simmons, 'Contemporary Cryptology', Wiley-IEEE Press, 1999.

20SA34 MACHINE LEARNING

3 2 0 4

Prerequisites:
20SA15 – Contemporary Algebra.
20SA14 - Probability, Stochastic Processes and Statistics

INTRODUCTION: Machine learning – Types – Supervised learning, unsupervised, Reinforcement learning, semi supervised learning (2)

SUPERVISED LEARNING: Regression – Linear – Polynomial – Multiple regression – Evaluation measures – Bias –variance –over fitting – under fitting – Regularization (8)

CLASSIFICATION: Linear classification – Logistic regression – linear discriminant analysis – Optimization – Convex set - Convex functions – Convexity checking - Loss functions for classification and regression - Gradient descent – variants – Perceptron - Support Vector Machines – Linear, Soft margin, Linearly non separable data - Kernel functions. (10)

NEURAL NETWORKS:: Multilayer perceptron - Back propagation – Training – Bayesian Classifier – Decision theory – Maximum A Posteriori estimate – maximum likelihood estimate K nearest neighbour classifier. (10)

DECISION TREES: Introduction – Purity measures – Entropy, cross entropy, information gain, gain ratio, Gini Index – Regression trees – ID3 – Pruning – Model selection – Bootstrapping and cross validation – Model evaluation – Performance Measures – Receiver operating characteristic curve (ROC) – AUC. (8)

UNSUPERVISED LEARNING: Clustering –Types - K-means – EM - Mixture of Gaussians –Spectral clustering - Cluster validity measures – dimensionality reduction- extraction – PCA (Principal components analysis) - ICA (Independent components analysis) - Applications : image segmentation – Image compression –Outlier analysis. (7)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Download the datasets from UCI machine learning repository / www.kaggle.com for classification and clustering.
    a. Mail spam
    b. Breast cancer data
    c. Iris data
    d. MNIST dataset

2. Implement the following Classification algorithms on the above suitable datasets.
    a. Naïve Bayes
    b. LDA / QDA
    c. SVM
    d. K nearest neighbour
    e. Multi layer Perception
3. Do tenfold cross validation experiments and statistical validation using t-test and ANOVA.
4. Apply clustering for image segmentation and image compression.
5. Apply Spectral clustering on data sets and visualization through plots
6. Apply PCA / LDA / Factor analysis on Iris data set, reduce the dimension and visualize the data .
7. Apply semi supervised learning techniques on data sets for the following tasks: to fill missing values / classification

TEXT BOOKS:

1. David Barber, 'Machine Learning: A Probabilistic Approach', http://www.idiap.ch/~barber, 2006.
2. AlpaydinEthem, 'Introduction to Machine Learning', Massachusetts Institute of Technology Press, 2020.

REFERENCES:

1. Trevor Hastie, Robert Tibshirani and Jerome Friedman, 'The Elements of Statistical Learning', Springer, 2013.
2. Christopher M Bishop, 'Pattern Recognition and Machine Learning', Springer, 2016.
3. Richard O Duda, Peter E Hart and David G Stork, 'Pattern Classification (Digitized)', John Wiley, 2016.

20SA37 SCIENTIFIC COMPUTING LAB

0 0 2 1

Prerequisites:

20SA11 Contemporary Algebra
20SA13 Differential Equations

1. Solution of algebraic and transcendental equations- Newton Raphson method, method of false position, Graeffe's root squaring Method.

2. Solving linear system of equations by direct method and iterative method- Gauss elimination method, Crout's method , Gauss- Seidel method.

3. Computing Eigenvalue and Eigenvectors.

4.Interpolation with unequal intervals and equal intervals.

5.Numerical Differentiation and Integration

6.Taylor's series method, Euler's method, Modified Euler's method Fourth order RungeKutta method for solving first order differential equations'

7. Numerical solutions of Solution of one dimensional heat equation by explicit and implicit methods – One dimensional wave equation and two dimensional Laplace and Poisson equation'

8. Solving LPP using simplex method and two phase method.'

TOTAL P: 30

TEXT BOOKS:

1. Steven C. Chapra and Raymond P. Canale, 'Nmerical Methods for Engineers with Software and Programming Applications', Mc-Graw Hill, 2011.

REFERENCES:

1. CurtisF. Gerald,andPatrickO. Wheatley, 'Applied Numerical Analysis', Pearson, 2011.
2. YousefSaad. 'Numerical methods for large eigenvalue problems', University Press, 2011.

20SA38 MINI PROJECT & SEMINAR

0 0 4 2

Mini – project is to be done during the summer vacation at the end of the second semester and a seminar is to be conducted during the third semester.

SEMESTER - IV

20SA40 PROJECT WORK

0 0 24 12

Every student shall undertake a project work during the fourth semester. The project work shall be undertaken in an industrial / research organization or in the college in consultation with the faculty guide and the Head of the Department. In case of the project work at industrial / research organization, the same shall be jointly supervised by a faculty guide and an expert from the organization.

PROFESSIONAL ELECTIVES

20SA61 ALGEBRAIC TOPOLOGY

3 2 0 4

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 - Topology and Functional Analysis.

ALGEBRAIC TOPOLOGY: Homotopy of Paths- The Fundamental Groups- Circle , group of S^n, Covering spaces- Retractions of fixed points- The fundamental theorem of Algebra. (9 + 6)

SEPARATION THEOREMS IN PLANE: The Jordan Separation Theorem—Invariance of domain-Jordan Curve Theorem- Imbedding graphs in a plane- Winding number of simple closed curve (10 + 7)

CLASSIFICATION OF SURFACES: Fundamental Groups of Surfaces-Homology of Surfaces- Cutting and pasting- The classification theorem- Constructing compact surfaces. (10 + 7)

AXIOMATIC APPROACH TO DIGITAL TOPOLOGY: Axioms of Digital Topology, Relation between the suggested and classical Axioms, Deducing the properties of ALF spaces from the axioms**.** (8 + 5)

ABSTRACT CELL COMPLEXES: Topology of complexes, Cartesian complexes and combinatorial coordinates, AC complexes compared with other Locally Finite Spaces (8 + 5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. James R. Munkres, 'Topology- A First Course', Pearson, 2018.
2. Allen Hatcher, 'Algebraic Topology', Cambridge University Press, 2002.

REFERENCES:
1. Herbert Edlesbrunner and John Harer, 'Computational Topology– An Introduction', AMS, 2010.
2. Vladimir A. Kovalevsky, 'Geometry of Locally Finite Spaces: Computer Agreeable Topology and Algorithms for Computer Imaginary', House Dr. BaerbelKovalevski, 2008.

20SA62 ARTIFICIAL INTELLIGENCE

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics,
20SA24 - Data structures

INTRODUCTION: The foundations of AI - The History of AI - Intelligent agents - Agent based system. (2)

PROBLEM SOLVING: State Space models - Searching for solution - Uninformed/Blind search - Informed/ Heuristic search - A* search - Hill-climbing search - Meta Heuristic: Genetic Algorithm - Adversary based search : Minimax – Expectimax – Alpha Beta pruning – Constraint satisfaction problem - Backtracking search. (10)

KNOWLEDGE REPRESENTATION AND REASONING: Knowledge representation - Logics - bivalent logic - inference - Fuzzy logic: membership - Fuzzy rules and reasoning - Fuzzy inference. (8)

UNCERTAIN KNOWLEDGE AND PROBABILISTIC REASONING: Uncertainty - Probabilistic reasoning - Semantics of Bayesian network - Exact inference in Bayesian network- Approximate inference in Bayesian network - Probabilistic reasoning over time – Inference in temporal models - Hidden Markov Models – Dynamic Bayesian Networks. (10)

DECISION-MAKING: Basics of utility theory, Utility functions - Sequential decision problems - Markov decision process - Value iteration - Policy iteration - Decisions in Multi agent system: Multi agent decision theory - Group decision making. (10)

LEARNING: Learning from observation – Supervised Learning: Neural networks - Unsupervised - Reinforcement learning. Robotics - Introduction. (5)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Implementation of blind search algorithms.
2. Implementation of Heuristic search algorithms like A* and Hill Climbing.
3. Solving 8 –puzzle and Missionaries and Cannibals problem.
4. Constraint satisfaction techniques
5. Logic based exercises.
6. Implementation of supervised and unsupervised learning algorithms.
7. Simple games – minimax and expectimax

TEXT BOOKS:

1. Stuart Russell and Peter Norvig, 'Artificial Intelligence: A Modern Approach', Pearson Education, 2020.
2. David Pool and Alan Mackworth, 'Atificial Intelligence: Foundations of Computational agents', Cambridge University Press, 2017.

REFERENCES:

1. Timothy Ross, 'Fuzzy Logic with Engineering Applications', John Wiley, 2016.
2. Tsang and Edward, 'Foundations of Constraint Satisfaction: The Classic Text', Academic Press, 2014.
3. Christopher M.Bishop, 'Pattern Recognition and Machine Learning', Springer, 2016.
4. Nils J. Nilsson, 'The Quest for Artificial Intelligence: A History of Ideas and achievements', Cambridge University Press, 2010.

20SA63 BIG DATA AND MODERN DATABASE SYSTEMS

3 2 0 4

Prerequisites:
20SA24 - Data structures,
20SA25 - Database Management System.

OBJECT AND SPATIAL DATABASES: Object Oriented Databases - Complex data types - Structured types and Inheritance – Query Processing in Object databases - Spatial Databases : Geometric Information System – Spatial Data Types – Spatial Queries - Spatial indexing techniques. (6)

PARALLEL AND DISTRIBUTED DATABASES: Architecture of parallel databases – Parallel query evaluation, Parallel Queryoptimization – Distributed DBMS Architecture, Distributed Database Design, Distributed Query Processing.. (5)

DATA MODELING FOR BIG DATA: Big Data and Challenges, Big Data models, NoSQL data models, Basic principles of NoSQL models, BASE properties, CAP Theorem, SQL databases VsNoSQL databases - MAP-REDUCE: Apache Hadoop andHDFS, SPARK. (10)

NOSQL DATABASES (PART 1): Key - Value Stores: Amazon DynamoDB, Key -Value Stores (in-memory) : Redis ColumnOriented Store: Google BigTable , Apache Cassandra - Hbase (10)

NOSQL DATABASES (PART 2): Document Oriented Stores – MongoDB - Apache CouchDB - Graph databases: Neo4J –Orient DB. (9)

DATABASE INTEGRATION: Data warehousing, Virtual Data Integration - Schema directed data integration - Schema mapping and information preservation (5)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Creating and querying object relational data base
2. Implementing of spatial database and spatial data queries.
3. Distribution using Map- Reduce onBig Data (Hadoop)
4. Data Integration from heterogeneous Databases.
5. Implementation of No-SQL databases : DynamoDB, MongoDB, HBASE, Neo4J.

TEXT BOOKS:

1. Pramod J. Sadalage and Martin Fowler, 'NoSQL Distilled - Brief Guide to the Emerging World of Polyglot Persistence', Pearson Education, 2013.
2. Guy Harrison, 'Next generation Databases: NoSQL and Big Data', Apress, 2015.
3. Kristina Chodorow, Mongon DB 'The Definitive Guide', O'Reilly Media, 2019.
4. Holden Karau, Andy Konwinski, Patrick Wendell, MateiZaharia, 'Learning Spark: Lightning - Fast Big Data Analysis', O'Reilly Media, 2015.

REFERENCES:

1. RamezElmasri and ShamkranthNavathe , 'Fundamentals of Database Systems', Addison Wesley, 2016.
2. M.TamerOzsu, Patrick Valduriez, 'Principles of Distributed Database Systems', Springer, 2020.
3. Anhai Doan, Alon Halevy, Zachary Ives, 'Principles of data integration', Morgan Kaufmann, 2012.

20SA64 CALCULUS OF VARIATIONS AND TRANSFORMS

3 2 0 4

Prerequisites::
20SA12 - Real Analysis,
20SA13 - Differential Equations.

INTEGRAL EQUATIONS: Introduction - Linear integral equation of the first and second kind of Fredholm and Volterra type - Solutions with separable kernels – Eigenvalues – Eigenfunctions - Resolvent kernel – Construction of Green's function for BVP. (9 + 6)

CALCULUS OFVARIATIONS: Functional - Variation of a functional - Euler-Lagrange equation - Necessary and sufficient conditions for extrema - Variational methods for boundary value problems in ordinary and partial differential equations. (8 + 5)

LAPLACE TRANSFORM: Definition - Transforms of Standard Functions - Transform of unit step and Dirac delta functions – Transforms of derivatives and integrals –Derivative and integrals of Transforms- Transforms of Periodic functions - Inverse Laplace transform- Convolution Theorem. Solving ordinary linear differential equations with constant coefficient and solving integral equations using Laplace transform. (10 + 7)

FOURIER TRANSFORM : Fourier integrals - Fourier transform- Fourier sine and cosine transform - Transforms of standard functions - Properties, Convolution theorem (Statement only) – Discrete Fourier and Fast Fourier Transforms – Discrete Convolution – Periodic sequence and circular convolution – Discrete Fourier Transform – decimation–in-time algorithm – Decimation-in-frequency algorithm – Computation of inverse DFT. (10 + 7)

Z-TRANSFORM: Z - transform of standard functions, inverse Z-transform – properties of Z – transform – Difference equations – Modeling and Solution of difference equations. (8 + 5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. Ram P. Kanwal, 'Linear Integral Equations: Theory and Technique', Birkhäuser, 2013.
2. I.M. Gelfand and S. V. Fomin, 'Calculus of Variations', Dover, 2000.
3. EwinKreyszig, 'Advanced Engineering Mathematics', John Wiley, 2015.

REFERENCES:
1. Ray Wylie C, Louis C Barret, 'Advanced Engineering Mathematics', McGraw Hill, 2003.
2. Michael D. Greenberg, 'Advanced Engineering Mathematics', Pearson Education, 2009.
3. Roland E. Thomas and Albert J. Rosa, 'The Design and Analysis of Linear Circuits', John Wiley, 2011.

20SA65 CLASSICAL MECHANICS

3 2 0 4

Prerequisites::
20SA12 - Real Analysis,
20SA13 - Differential Equations.

THE MECHANICAL SYSTEMS: Introductions, basic properties Generalized coordinates- Constraints - Virtual work - Energy and momentum. (9 + 6)

LAGRANGE'S EQUATIONS: Introduction to Lagrange' s equations, Derivation of Lagrange's equations - Examples - Integrals of the motion. (10 + 7)

HAMILTON'S EQUATIONS: Introduction, Hamilton's principles, Hamilton's equations – Other variational principles. (10 + 7)

HAMILTON – JACOBI THEORY: Hamilton's principal function - The Hamilton – Jacobi equation - Separability. (8 + 5)

CANONICAL TRANSORMATIONS: Differential forms and generating functions - Special transformations - Lagrange and Poisson brackets (8 +5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. Donald T. Greenwood, Classical Dynamics, Dover Publication,1997.
2. Herbert Goldstein, Charles Poole, John Safko, Classical Mechanics, Pearson Education, 2002.

REFERENCES:
1. David Morin, Introduction to Classical Mechanics with problems and solutions, Cambridge University press, 2008.
2. R. Douglas Gregory, Classical Mechanics, Cambridge University press, 2006.

20SA66 COMPUTAIONAL FINANCE

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

INTRODUCTION: Computational finance - Cash Flow Streams - Investments and the Market – Forwards, Futures, and Options –No arbitrage and the Law of One Price–Forwards–Futures–Option type, style, and payoff–Put-Call Parity for European options–Put-Call Parity bounds for American options. (5)

MATHEMATICAL PRELIMINARIES : Univariate distributions - quantiles of a distribution, Value-at-Risk – Bivariate distributions - Covariance, correlation, autocorrelation, linear combinations of random variables - Time series analysis: Covariance stationarity, autocorrelations, MA(1) and AR(1) models – Descriptive statistics - Stochastic calculus Martingales and Brownian motion. (10)

PORTFOLIO THEORY - Introduction - Review of constrained optimization methods, Markowitz algorithm, Markowitz Algorithm using the solver and matrix algebra – Markowitz algorithm with no short sales constraints-Portfolio risk budgeting– Statistical analysis of efficient portfolios. (10)

BASIC OPTIONS THEORY – Definitions – Pay off diagrams – Single period binomial options theory – Multi period binomial options theory – Real options-Simulation methods for options pricing. (10)

THE CAPITAL ASSET PRICING (CAP) AND RISK BUDGETING : Mean variance portfolio theory – Asset returns Variance as a risk measure - The one and two fund theorems – The capital market line – CAP as a pricing formula Systematic and unsystematic risk – Euler's theorem – Asset contributions to volatility –Beta as a measure of portfolio risk-limitations. (10)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Obtaining financial data, computing returns, plotting and basic analysis
2. Working with time series data
3. Linear time series modeling andforecasting
4. Modeling volatility: Volatility forecasting for risk management
5. Portfolio optimization: Mean-variance model
6. Tangency portfolio and Capital MarketLine
7. Asset Pricing model: Capital Asset Pricing Model, Beta estimation
8. Estimating the Term Structureof Interest Rates
9. Derivatives Pricing: The Black-Scholes model, The Cox-Ross-Rubinstein model.

TEXT BOOKS:
1. David Ruppert, 'Statistics and Data Analysis for Financial Engineering', Springer, 2013.
2 . MarekCapinski and Tomasz Zastawniak, 'Mathematics for Finance', Springer, 2011.

REFERENCES:
1. John C. Hull, 'Options, Futures and Other Derivatives', Pearson Education, 2016.
2. Steven E Shreve, 'Stochastic Calculus for Finance – I' , Springer, 2005.
3. Sheldon M. Ross, 'An Elementary Introduction to Mathematical Finance', Cambridge University Press, 2011.

20SA67 DATA MINING

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics.

INTRODUCTION: Data mining, kinds of data, kinds of patterns, major issues in data mining; Data objects and attribute types, measuring data similarity and dissimilarity. (6)

DATA PREPROCESSING: Data pre-processing, data cleaning, data integration, data reduction' (5)

MINING FREQUENT PATTERNS, ASSOCIATIONS AND CORRELATIONS: Basic concepts, frequent item set mining methods, apriori algorithm, FP tree, pattern evaluation methods. . (9)

CLASSIFICATION: Basic concepts, decision tree induction, Bayes classification methods, model evaluation and selection, metrics for evaluating classifier performance, Holdout methods and Random sub sampling, Cross-validation and ROC Curves, Techniques to improve classification accuracy, Bagging, Boosting and AdaBoost. (9)

CLUSTER ANALYSIS: Cluster analysis, partitioning methods, K-means, K-medoids, hierarchical methods, agglomerative versus divisive hierarchical clustering, density-based methods. (9)

TRENDS IN DATA MINING: Mining distributed heterogeneous and legacy databases, Multimedia data mining, Data mining and theWorld Wide Web, Security and Privacy issues for data mining,
Case Studies:
Text mining: extracting attributes (keywords), Bayesian approach to classifying text
Web mining: classifying web pages, extracting knowledge from the web
Graph Mining: Sub-structure matching (7)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Implementation of data mining techniques using WEKA.
2. Implementation of Association rule mining using Apriori algorithm and FP Growth algorithm
3. Classification rules using Decision Tree classifier, Ensemble of Classifiers.
4. Implementation of clustering algorithms
5. Case studies using R programming.

TEXT BOOKS:
1. Jiawei Han, MichelineKamber and Jian Pei, 'Data Mining – Concepts and Techniques', Reed Elsevier, 2012.
2. Tan, Steinbach and Kumar, 'Introduction to Data Mining', Pearson Education, 2013.
3. Trevor Hastie, Robert Tibshirani and Jerome Freidman, 'The Elements of Statistical Learning: Data Mining, Inference, and Prediction', Springer Series in Statistics, 2009.

REFERENCES:
1. Ian Witten, Frank Eibe and Mark A Hall, 'Data Mining: Practical Machine Learning Tools and Techniques"' Elsevier, 2011.
2. Charu C. Aggarwal, Haixun Wang, 'Managing and Mining Graph Data', Springer, 2010.
3 .Michael W. Berry, Jacob Kogan, 'Text Mining: Applications and Theory', Wiley, 2010.

20SA68 DESIGN AND ANALYSIS OF ALGORITHMS

3 2 0 4

Prerequisites:
20SA15- Discrete Mathematics,
20SA24 - Data Structures.

INTRODUCTION: Algorithm – analysis of algorithms – best case and worst case complexities. Asymptotic notations-Master's Theorem. (3)

SORTING ALGORITHMS: Insertion sort- Selection sort- Heap sort-Radix sort-time complexity analysis. (3)

DIVIDE AND CONQUER: Method – examples – Merge sort, Quick sort, Strassen's matrix multiplication, Closest Pair. (6)

GREEDY METHOD: Optimization problems – method – examples – Minimum cost spanning tree (Kruskal'sand prim'salgorithms), Topological sorting, Huffman coding, Fractional knapsack. (8)

DYNAMIC PROGRAMMING: Method – examples –0/1 Knapsack-All pairs shortest path problem -Traveling salesman problem. (6)

NETWORK FLOW: Flows and Cuts-Max flow mincut theorem-Ford Fulkerson's Algorithm (5)

NP-HARD, NP-COMPLETE CLASSES: Basic concepts – Non deterministic algorithms – satisfiability problem – NP-hard and NP-complete Problems – Cooks theorem (statement only)- Reduction- Vertex cover. (6)

BACK TRACKING: Method – Examples – Eight queen's problem, Hamiltonian Cycles. (4)

BRANCH &BOUND: Method – Example – 0/1 knapsack-Traveling salesman problem (4)

Total L : 45 + T: 30 = 75

Tutorial Practices:
. Implementation of the following problems:
1. Divide and Conquer versions of Merge sort, Quick sort, binary search and closest pair
2. Greedy method implementation of Topological sort, Minimum cost spanning tree.
3. Dynamic Programming implementation of Traveling Salesperson problem.
4. Eight queen's problem backtracking algorithm.
5. Knapsack using branch and bound algorithm

TEXT BOOKS:
1. Thomas H. Cormen, Charles E. Leiserson, and Ronald LRivest, 'Introduction to Algorithms', MIT Press, 2015.
2. Jon Kleinberg and Eve Tardos, 'Algorithm Design', Pearson Education, 2013.

REFERENCES:
1. AnanyLevitin, 'Introduction to Design and Analysis of Algorithms', Pearson Education, 2012.
2. Michael T. Goodrich and Roberto Tamassia, 'Algorithm Design, Foundations, Analysis, and Internet Examples', Wiley, 2014.

20SA69 DIGITAL IMAGE PROCESSING AND COMPUTER VISION

3 2 0 4

Prerequisites:
20SA24 - Data Structures.

DIGITAL IMAGE FUNDAMENTALS: Image Sampling and Quantization, Digital Image Representation, Image Types, Pixel neighborhood. (3)

IMAGE ENHANCEMENT: Noise models, Point Operations, Histogram Processing, Spatial Operations, Multispectral Image Enhancement, Color Image Enhancement. Image Transforms - Fourier Transform, Discrete Cosine Transform, \Wavelets. (6)

EDGE DETECTION: The Purpose of Edge Detection, Traditional Approaches and Theory, Edge Models, Comparison of Two Optimal Edge Detectors, Color Edges. (5)

DIGITAL MORPHOLOGY: Connectedness, Binary Operations, Dilation and Erosion, Opening and Closing, Grey-Level Morphology, Color Morphology. (4)

GREY-LEVEL SEGMENTATION: Basics of Grey-Level Segmentation, The Use of Regional Thresholds, Moving Averages, Cluster-Based Thresholds, Multiple Thresholds, Region-based segmentation, Watershed Transform. (9)

IMAGE RESTORATION: Image Degradations, The Frequency Domain, The Inverse Filter, The Wiener Filter, Structured Noise, Motion Blur, The Homomorphic Filter, Least Square Filters, Generalized Inverse & Iterative Methods, Recursive filtering, Bayesian Methods. (9)

IMAGE ANALYSIS AND CPMPUTER VISION: Feature Extraction - color, texture and shape features, Dimensionality Reduction, Clustering and Classification. (9)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Basic image processing techniques like sampling and quantization
2. Implementation of Image segmentation and edge detection.
3. Implementation of Histogram equalization.
4. Implementation of 2-D DFT and DCT.
5. Implementation of feature extraction.
6. Implementation of image filtering methods in spatial and frequency domain.
7. Image restoration.
8. Implementation of image classification and clustering.
9. Developing simple image analysis applications.

TEXT BOOKS:
1. Rafael C Gonzalez and Richard E Woods, 'Digital Image Processing", Prentice Hall, 2011.
2. Kenneth R Castleman, "Digital Image Processing", Pearson Education, 2007.

REFERENCES:
1. Maria Petrou , Costas Petrou, "Image Processing: The Fundamentals", John Wiley& Sons, 2010.
2. Anil K Jain. "Fundamentals of Digital Image Processing", Prentice Hall, 2001.

20SA70 EPIDEMIC MODELS

3 2 0 4

Prerequisites:
20SA13 – Differential Equations,
20SA14 - Probability, Stochastic Processes and Statistics

BASICS OF EPIDEMICS: The epidemic in a closed population – Initial growth-the final size. Heterogeneity: Differences in infectivity, differences in infectivity and susceptibility. (8 + 5)

STRUCTURED POPULATIONS: The concept of state-i-states, p-states, recapitulation and problem formulation (8 + 5)

THE BASIC REPRODUCTION RATIO: The definition of R_0, general h-state, on conditions that simplify the computation of R_0, sub models for the kernel, extended example, pair formulation models. Partially vaccinated populations, the intrinsic growth rate r, some generalities, separable mixing. (15 + 11)

MACROPARASITES: Introduction, counting parasite load, the calculation of R_0 for life cycles, seasonality and R_0, a pathological mode. (8 +5)

CONTACT: Introduction, Contact duration, consistency conditions, effects of subdivision, network models. (6 + 4)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. O.Diekmann, J.A.P. Heesterbeek, "Mathematical Epidemiology of Infectious Diseases: Model building, Analysis and Interpretation", John Wiley, 2000.
2. Roy M. Anderson and Robert M. May, "Infectious diseases of humans; dynamic and control" Oxford university Press, 1992.

REFERENCES:
1. Diekmann O., Heesterbeek, J.A.P. and Britton, T. Mathematical tools for understanding infectious disease dynamics. Princeton, Univ. Press, 2012.

20SA71 GAME THEORY

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

INTRODUCTION: Basic concepts -Theory of rational choice – Interacting decision makers (2)

STRATEGIC GAMES AND NASHEQUILIBRIUM: Strategic games: Examples –Nash equilibrium: concept and examples -Best response – Dominated actions –Symmetric games and symmetric equilibria- Illustrations: Cournot's and Bertrand's models of duopoly,Electoral competition, War of Attrition , Auctions, Accident Laws. (8 + 6)

MIXED STRATEGY NASHEQUILIBRIUM::Introduction, Strategic games with randomization- Mixed strategy Nash equilibrium: concept and examples - Dominated Actions -Formation of Players' beliefs - Illustrations: Expert diagnosis, Reporting a crime. (6 + 4)

EXTENSIVE GAMES WITH PERFECT INFORMATION: Strategies and outcomes – Nash equilibrium – Sub game perfect equilibrium –Backward induction - Illustrations: Stackelberg's model of duopoly, Buying votes, Ultimatum game. (6 + 4)

GAMES WITH IMPERFECT INFORMATION: Bayesian games – Examples – Strategic information – Transmission – Agenda Control with imperfect Information – Signaling games - Education as a signal of ability. (6 + 4)

REPEATED GAMES: Nash equilibrium in repeated games, finitely and infinitely repeated Prisoner's Dilemma - – Sub game – Perfect equilibria and the one – deviation – Property – General results – Finitely replaced games – Variation on a theme: Imperfect observability. (6 +5)

BARGAINING: Rubinstein Bargaining Model with Alternating Offers -Nash Bargaining Solution- Relation of Axiomatic and Strategic Model- Illustration: Trade in market. (5 +3)

AUCTION AND MECHANISM DESIGN: introduction- The Vickery auction- Sponsored Search auction- Social Choice theory- VCG mechanism. (6 + 4)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. Martin J. Osborne, 'An Introduction to game theory', Oxford University Press, 2004.
2. Nisan N., Roughgarden T.,Tardos E., Vazirani V., 'Algorithmic Game Theory', Cambridge University Press, 2007.

REFERENCES:
1. Thomas L.C, 'Games, Theory and Applications', Dover Publications, 2011.
2. Ken Binmore, 'Playing for Real: A Text on Game Theory', Oxford University Press, 2007.
3. David Easley, Jon Kleinberg, 'Networks, Crowds, and Markets: Reasoning About a Highly Connected World', Cambridge University Press, 2010.
4. Matthew O. Jackson, 'Social and Economic Networks', Princeton University Press, 2008.

20SA72 GEOMETRY OF LOCALLY FINITE SPACES

3 2 0 4

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 – Topology and Functional Analysis.

AXIOMATIC APPROACH TO DIGITAL TOPOLOGY: Axioms of Digital Topology, Relation between the suggested and classical Axioms, Deducing the properties of ALF spaces from the axioms**.** (8 + 5)

ABSTACT CELL COMPLEXES: Topology of complexes, Cartesian complexes and combinatorial coordinates, AC complexes compared with other Locally Finite Spaces. (10 + 7)

COMBINOTORIAL HOMEOMORPHISM: Definition of combinatorial homeomorphism, balls and spheres, generalized boundary and boundary of space, orientation of AC complexes, combinatorial manifolds, block complexes, consistency of the (m,n)-adjacencies. (10 + 7)

MAPPINGS AMONG LOCALLY FINITE SPACES: Connected –Preserving Mappings **(CPM),** the combinatorial homeomorphism, properties of manifolds and block complexes. (8 + 5)

HOMOLOGY: Homology of groups, matrix reduction, relative homology, exact sequences, co-homology. (9 + 6)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1.Vladimir A. Kovalevsky, 'Geometry of Locally Finite Spaces: Computer Agreeable Topology and Algorithms for Computer Imaginary', House Dr. Baerbel Kovalevski,2008.
2.Herbert Edlesbrunner and John Harer, Computational Topology An Introduction', AMS,2010.

REFERERNCES:
1. James R. Munkres, 'Topology- A First Course', Pearson, 2018.
2. Allen Hatcher, 'Algebraic Topology', Cambridge University Press, 2002.

20SA73 INFORMATION RETRIEVAL AND WEBSEARCH

3 2 0 4

Prerequisites:
20SA11 – Contemporary Algebra,
20SA14 – Probability, Stochastic Processes and Statistics,
20SA24 - Data structures.

INTRODUCTION: Overview of IR Systems - Historical Perspectives - Goals of IR - The impact of the web on IR - The role of artificial intelligence (AI) in IR. (3)

TEXT REPRESENTATION: Statistical Characteristics of Text: Zipf's law; Porter stemmer; morphology; index term selection; using thesauri. **Basic Tokenizing, Indexing:** Simple tokenizing, stop-word removal, and stemming; inverted indices; Data Structure and File Organization for IR - efficient processing with sparse vectors. (6)

RETRIEVAL MODELS: Similarity Measures and Ranking - Boolean Matching – Extended Boolean models – Ranked retrieval - Vector Space Models -, text-similarity metrics - TF-IDF (term frequency/inverse document frequency) weighting - cosine similarity, Probabilistic Models, Evaluations on benchmark text collections. (8)

QUERY PROCESSING: **Query Operations and Languages**- Query expansion; Experimental Evaluation of IR: Performance metrics: recall, precision, and F-measure. (5)

TEXT CATEGORIZATION AND CLUSTERING: Categorization: Rocchio; Naive Bayes, kNN; Clustering: Agglomerative clustering; k-means; Expectation Maximization (EM); Dimension Reduction: LSI, PCA. (6)

INFORMATION FILTERING TECHNIQUES: introduction to Information Filtering, Relevance Feedback - Applications of Information Filtering: **RECOMMENDER SYSTEMS**: Collaborative filtering and Content-Based recommendation of documents and products. (6)

WEB SEARCH: IR Systems and the WWW - Search Engines: Spidering, Meta Crawlers; Link analysis: Hubs and Authorities, Google PageRank, Duplicate Detection, (5)

INFORMATION EXTRACTION AND INTEGRATION: Extracting data from text; Basic Techniques: Named Entity

Recognition, Co-reference Resolution, Relation Extraction, Event Extraction; Extracting and Integrating specialized information on the Web, Web Mining and Its Applications. (6)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Different retrieval models - Boolean, Vector space and Probability based retrieval.
2. Query refinement techniques
3. Evaluation of the retrieval algorithms.
4. Dimension Reduction techniques
5. Classification and Clustering techniques
6. Recommender systems- Collaborative and Content Based Filtering
7. Information Extraction techniques
8. Web based retrieval - Link based retrieval, combining content and link information.

TEXT BOOKS:

1. Christopher D. Manning, PrabhakarRaghavan and HinrichSchütze, 'Introduction to Information Retrieval', Cambridge University Press, 2012.
2. B.Croft, D. Metzler, T. Strohman, 'Search Engines: Information Retrieval in Practice', Pearson Education, 2015.

REFERENCES:

1. Stefan Büttcher, Charles L. A. Clarke, Gordon V. Cormack, 'Information Retrieval – Implementing and Evaluating Search Engines', The MIT Press, 2016
2. Ricardo Baeza-Yates and BerthierRibeiro-Neto, 'Modern Information Retrieval', Pearson Education, 2010.
3. Francesco Ricci, LiorRokach, BrachaShapira, Paul B. Kantor, 'Recommender Systems – Handbook', Springer, 2015.

20SA74 MATHEMATICAL MODELING

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

INTRODUCTION TO MODELING: Modeling process, Overview of different kinds of model. (2)

EMPIRICAL MODELING WITH DATA FITTING: Error function, least squares method; fitting data with polynomials and Splines. (4)

CAUSAL MODELING AND FORECASTING: Introduction, Modeling the causal time series, forecasting by regression analysis,predictions by regression. Planning, development and maintenance of linear models, trend analysis,modeling seasonality and trend,trend removal and cyclical analysis, decomposition analysis. Modeling financial time series. Econometrics and time series models.Non seasonal models: ARIMA process for univariate and multivariate. (10)

PORTFOLIO MODELING AND ANALYSIS: Portfolios, returns and risk, risk-reward analysis, asset pricing models, mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm, Capital Asset Pricing Models (CAPM). (12)

DISCRETE-TIME FINANCE: Pricing by arbitrage, risk-neutral probability measures, valuation of contingent claims, and fundamental theorem of asset pricing, Cox-Ross-Rubinstein (CRR) model, pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives (5)

MODELING WITH BIOINFORMATICS: Introduction, Biological data- types, mode of collection, documentation and submission. Sequence alignment- Definition, significance, dot matrix method, dynamic programming- Global and local alignment tools, scoring matrices and gap penalties. Multiple sequence alignment: Iterative methods. (12)

Total L : 45 + T :30 = 75

Tutorial Practices:

1 Least square method for fitting data
2. Modeling financial time series
3. ARIMA process
4. Markowitz model for portfolio modeling
5. Capital asset pricing models
6. CRR model
7. Sequence alignment by using dynamic programming technique
8. Multiple sequence alignment.

TEXT BOOKS:

1. Giordano F R, Weir M D, and Fox W P, 'A First Course in Mathematical Modeling'. Brooks/Cole, Belmont, 2014.

2. Capinski M. and ZastawniakT,'Mathematics for Finance: An Introduction to Financial Engineering', Springer, 2011.
3. Mount. DW, 'Bioinformatics Sequence and Genome Analysis', Cold Spring Harbor Laboratory, Press, 2006.

REFERENCES:

1. Hamdy A. Taha, 'Operation Research- An Introduction', Pearson Education, 2012.
2. Christoffersen. P, 'Elements of Financial Risk Management', Academic Press,2012.
3. G.Polya, ' How to Solve it: : New Aspect of Mathematical Method', Princeton University Press, 2018.

20SA75 MOBILE APPLICATION AND DEVELOPMENT

3 2 0 4

Prerequisites:
20SA23 - Object oriented programming.

MOBILE AND WIRELESS DEVICES: Introduction - Evolution of mobile communication generations- Challenges in mobile computing – Vertical and horizontal mobile applications. (8)

CELLULAR CONCEPT: Wireless transmission - Frequencies for radio transmission - Regulations - Signals , Antennas, Signal propagation ,Path loss of radio signals , Additional signal propagation effects - Multi-path propagation – Cell Concept - Factors determining cell size and shape. (10)

MOBILE APPLICATIONS ARCHITECTURE: Smart Client – Smart Client Architecture – Messaging Architecture The Model-View-Controller Model - Delegate Pattern- Building Smart Client Applications**-**Design, Development, implementation, testing and deployment phase- MVVM mobile architecture design. (10)

MOBILE APPLICATION DEVELOPMENT: Introduction to Android Platform – Android architecture overview - Application life cycle - UI design for Android - UI fragments - Different types of layouts – Widgets – List view – View pager – Dialogs, (10)

DATABASE: Files and database – SQLite on Android – Loading asynchronous data - Map API. (7)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Android SDK installation and study
2. Defining Layouts
3. Single Activity Application, Application with multiple activities, using intents to Launch Activities
4. Application using GUI Widgets
5. Application with Notifications
6. Creating and Saving Shared Preferences and Retrieving Shared Preferences
7. Usage of SQLite Databases for storage
8. Working with Retrofit library in Android Applications
9. Android Automated Testing Frameworks
10. Case Study: Dagger Framework for Android .

TEXT BOOKS:

1. Jochen Schiller, 'Mobile Communications', Pearson Education, 2012.
2. Bill Philips, Kristin Marsicano and Chris Stewart, 'Android Programming: The big Nerd Ranch guide', O'Reilly, 2017.
3. MartynMallick, 'Mobile and Wireless Design Essentials', Wiley, 2003.

REFERENCES::

1. Ronan Schwarz, Phil Dutson, James Steele and Nelson To, 'The Android Developer's Cookbook -Building Applications with theAndroid SDK', Addison Wesley, 2013**.**

20SA76 OPERATING SYSTEMS

3 2 0 4

INTRODUCTION: Abstract view of an operating system - Operating Systems Objectives and Functions – Evolution of Operating Systems - Dual-mode operation - System calls- Structure of Operating System. (3)

PROCESS DESCRIPTION AND CONTROL: Process concepts - Process Creation – Process Termination – Process states - Process Description – Process Control (3)

PROCESS AND THREADS: Relationship between process and threads – Thread States – Thread Synchronization Types of Thread – Multithreading model. (4)

PROCESS SCHEDULING: Scheduling basics - CPU-I/O interleaving- (non-)preemption - context switching- Types of **]**Scheduling – Scheduling Criteria - Scheduling Algorithms – Algorithm evaluation – Real-time scheduling**.** (5)

PROCESS SYNCHRONIZATION: Concurrent Process – Principles of Concurrency – Race Condition - Mutual Exclusion – Critical section problems – Software support – Hardware Support – Operating System Support: Semaphore, Monitor – Classical problems of synchronization – Synchronization examples. (4)

DEADLOCK:Principles- Characterization – Methods for handling deadlock - Deadlock prevention, Avoidance, Detection, and recovery. (4)

MEMORY MANAGEMENT: Memory hierarchy –Memory Management requirements - Memory partitioning: Fixed partitioning, Dynamic partitioning, Buddy systems – Simple paging – Page table structures – Simple Segmentation – segmentation and paging. (6)

VIRTUAL MEMORY MANAGEMENT: Need for Virtual Memory management – Demand Paging –Copy on write - Page Fault handling - Page replacement - Frame allocation- Thrashing - working set model. (5)

I/O MANAGEMENT AND DISK SCHEDULING: Organization of I/O function – Evolution of I/O function – Types of I/O devices – Logical Structure of I/O functions – I/O Buffering – Disk I/O – Disk Scheduling algorithms – RAID - Disk Cache. (4)

FILE SYSTEM MANAGEMENT: Files – Access methods - File system architecture – Functions of file management –Directory and disk structure -Mounting - File sharing –File system implementation – Directory implementation - File Allocation – Free space management. (4)

VIRTUALIZATION: Requirements for Virtualization - Type 1, Type 2 Hypervisors – Paravirtualization- Memory Virtualization - I/O Virtualization - Virtual machines on Multicore CPUs–Virtualization in Multiprocessor environment. (3)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Practicing UNIX Commands
2. Writing SHELL Scripts
3. Writing programs using UNIX System Calls
4. Process Creation and Execution
5. Thread Creation and Execution
6. Process / Thread Synchronization using semaphore
7. Developing Application using Inter Process communication (using sharedmemory, pipes or message queues)
8. Implementation of Memory Management Schemes
9. Implementation of file allocation technique (Linked, Indexed, Contiguous).

TEXT BOOKS:

1. Silberschatz A, Galvin, PB. and Gagne, G. 'Operating System Concepts', John Wiley & Sons, Inc.,2018.
2. William Stallings, 'Operating Systems: Internals and Design Principles', Pearson Education, 2017.
3. Andrew S Tanenbaum, 'Modern Operating System', Prentice Hall, 2018.

REFERENCES:

1. Elmasri, E., Carrick A.G. and Levine, D. 'Operating Systems: A Spiral Approach', McGraw Hill, 2014.
2. McHoes, AM and Flynn, I.M. 'Understanding Operating Systems', Cengage Learning, 2016.
3.Dhamdhere D M, 'Operating Systems: A Concept-based Approach', McGraw-Hill, 2015.

20SA77 PREDICTIVE ANALYTICS

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics

DATA WRANGLING : DataIngest, Data Cleaning - Exploratory data analysis - Univariate data – Bivariate data, Multivariate data. (5 + 3)

LINEAR REGRESSION: Coefficient of determination, Significance test, Residual analysis, Confidence and Prediction intervals. (5 + 3)

MULTIPLE LINEAR REGRESSION: Coefficient of determination, Interpretation of regression coefficients, Categorical variables, heteroscedasticity, Multi-co linearity outliers, Auto regression and Transformation of variables, Regression, Model Building (10 + 7)

LOGISTIC AND MULTINOMIAL REGRESSION: Logistic function, Estimation of probability using Logistic regression, Variance, Wald Test, HosmerLemshow Test, Classification Table, Gini Co-efficient. (5 + 3)

DECISION TREES: introduction, CHI-Square Automatic Interaction Detectors (CHAID), Classification and

Regression Tree(CART), Analysis of Unstructured data. (5 + 3)

FORECASTING: Moving average, Exponential Smoothing, Casual Models. (5 + 3)

TIME SERIES ANALYSIS: Moving Average Models, ARMA, ARIMA models , Multivariate Models. (5 + 3)

CASE STUDIES : Application of predictive analytics in retail, direct marketing, health care, financial services, insurance, supplychain, Social mediaanalytics– Customer Analytics - Risk Analytics - Analytics for Retail and Ecommerce, etc- Working with datafrom different sources: spreadsheets, databases, and the cloud -Model Development- Model Validation. (5 + 5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. Daniel T. Larose, Chantal D. Larose, 'Data Mining and Predictive Analytics', Wiley,2015
2. Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulachi, 'Introduction to Time Series Analysis and Forecasting',Wiley, 2015.
3. Max Kuhn, Kjell Johnson, 'Applied Predictive Modeling', Springer, 2014.

REFERENCES:
1. Richard A. Johnson, Irwin Miller and John Freund, 'Probability and Statistics for Engineers', Pearson Education, 2014.
2. Ronald E. Walpole, Raymond H. Meyers, Sharon L. Meyers, 'Probability and Statistics for Engineers and Scientists', Pearson Education, 2014.
3. Thomas W.Miller, 'Modeling Techniques in Predictive Analytics with Python and R A guide to Data Science', Pearson Education, 2014.

20SA78 STATISTICAL LEARNING

3 2 0 4

Prerequisites:
20SA12 – Real Analysis,
20SA14 – Probability, Stochastic Processes and Statistics,
20SA21 - Topology and Functional Analysis

THEORETICAL FOUNDATIONS : Review of Statistical Inference, Review of Probability, Testing of Hypothesis – Introduction to FunctionSpaces – Vector Spaces - Metric Spaces – Cauchy Sequence – Complete Metric Space – Normed Space, Inner Product Space – BanachSpace - Hilbert Space – Sobolev– Examples - Mercer Kernels - Reproducing Kernel Hilbert Space (RKHS), Concentration of Measure Measures of Complexity - Rademacher Complexity. (10)

LINEAR REGRESSION: Simple, Multiple, Other Considerations in the Regression Model – Resampling Methods Cross-Validation, Bootstrap– Linear Model Selection & Regularisation – Subset Selection , Shrinkage Methods – Ridge, Lasso, Dimension Reduction Methods, (8)

NON-LINEAR REGRESSION : Polynomial Estimators, Step Functions, Basis Functions, Regression Spline Smoothing Splines, Local Regression, Generalised Additive Models. (4)

LINEAR CLASSIFICATION: Review of Classification Models, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Comparison of Classification Methods. (6)

TREE BASED METHODS: Regression Trees, Classification Trees, Bagging, Random Forests, Boosting. (9)

SUPPORT VECTOR MACHINES: Maximal Margin Classifier – Support Vector Classifiers - Support Vector Machines – Non-linear DecisionBoundaries – SVMs with more than 2 classes. (4)

UNSUPERVISED LEARNING: Principal Components Analysis – Clustering Methods – K-Means Clustering, Hierarchical Clustering (4)

Total L : 45 + T: 30 = 75

Tutorial Practices:
Solve the following problems using R
1. Simple Regression, Multiple Regression, Ridge Regression and Lasso Regression.
2. Non-linear Regression, Splines and Additive Models
3. Linear Classification,
4. Tree based methods
5. Support Vector machines
6. Clustering Methods

TEXT BOOKS:
1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, "An introduction to Statistical learning", Springer, 2013.

2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, “Elements of Statistical Learning: Data Mining, Inference and Prediction”, Springer,2013.

REFERENCES:

1. Vladimir N Vapnik, “Statistical learning theory”, Wiley, 1998.
2. Robert Schapire, Yoav Freund, “Boosting : Foundations and Algorithms”, The MIT Press, 2012.

20SA79 STOCHASTIC DIFFERENTIAL EQUATIONS

3 2 0 4

Prerequisites:
20SA13- Differential Equations,
20SA15- Probability, Stochastic Processes and Statistics.

MATHEMATICAL PRELIMINARIES: Probability spaces - Random variables - Stochastic processes – Brownian motion. (7 +4)

ITO STOCHASTIC CALCULUS: Ito Integrals - Construction of its integrals - Properties (9 +6)

THE ITO FORMULA AND THE MARTINGALE REPRESENTATION THEOREM: The one-dimensional Ito formula - The multi-dimensional Ito formula – The Martingale representation theorem (9 + 6)

STOCHASTIC DIFFERENTIAL EQUATIONS: Construction of stochastic differential equations - an existence and uniqueness result- weak and strong solutions. (10 + 7)

METHOD OF SOLVING STOCHASTIC DIFFERENTIAL EQUATIONS: Linear stochastic differential equations - Reducible stochastic differential equations - Some explicitly solvable equations. (10 + 7)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

1. Peter E Kloeden and EckhardPlaten,’Numerical Solution of Stochastic Differential Equations’, Springer, 2018.
2. BerntOksendal , ‘Stochastic Differential Equations - An Introduction with Applications’, Springer, 2016.

REFERENCES:

1. Sasha Cyganowski, Peter Kloeden and Jerry Ombach, ‘From Elementary Probability to Stochastic Differential Equations with Maple’, Springer, 2002.

20SA80 TOPOLOGICAL DATA ANALYSIS

3 2 0 4

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 - Topology and Functional Analysis.

COMPLEXES: Topological spaces, Continuity, Connectedness, Surfaces, Homeomorphisms, Homotopy, Isotopy, Simplices, Simplicial Complex, Euler characteristics. (6+4)

HOMOLOGY : Simplical Homology, Chain complexes, Cycles and boundaries, Homology groups and Betti numbers, The homology of a ball, Reduced homology, Induced maps, Matrix reduction: Euler-Poincaré formula, Boundary matrices, Smith normal forms, Reduction algorithm; Relative homology groups; Excision, Maps between vector spaces, Exact sequences: Chain complexes and chain maps, The snake or zig-zag, Connecting homomorphism, Mayer-Vietoris sequence, cohomology (12+8)

MORSE THEORY: Generic smooth functions, Morse functions, Morse lemma, Gradient vector field on a manifold, Attaching cells, Transversality, Integral lines, Stable and unstable manifolds, Morse-Smale functions, Morse-Smale complexes, Morse inequalities, Floer homology, Relation between Morse theory and Homology. (10+7)

PERSISTENT HOMOLOGY: The elder rule, Filtrations, Persistence, diagrams, Matrix reduction, Pairing lemma, Sparse matrix representation, Extended persistence, Spectral sequence, Stability, Bottleneck distance, Tame functions, Wasserstein distance, Length and total curvature of a curve using stability, Bipartite graph matching for computing bottleneck distance. (10+7)

DATA-STRUCTURES: Piecewise-linear functions, Scalar data analysis: Contour tree and Reeb graph, Vector data analysis. (7+4)

TEXT BOOKS:

1 .Herbert Edlesbrunner and John Harer, ‘Computational Topology – An Introduction’, AMS, 2010.

2. James R. Munkres, 'Topology- A First Course', Pearson, 2018.
3. JamesR. Munkres." Elements of Algebraic Topology'. CRC Press, 2018.

REFERENCES:

1. John M.Lee, 'Introduction to Topological Manifold, Springer, 2011.
2. G unter Rote and GertVegter.'Computational Topology - An introduction (Effective Computational Geometry for Curves and Surfaces (Chapter 7)), Springer, 2006.