ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI, CALICUT

CURRICULUM AND SYLLABI

FOR

B.Sc. ECONOMICS & MATHEMATICS (DOUBLE MAIN)

(UNDER CHOICE BASED CREDIT & SEMESTER SYSTEM UG - 2019)

(EFFECTIVE FROM 2020 ADMISSION)

COURSE DESCRIPTION AND PROVISIONS

(As per SJCBCSS UG 2019 Regulations)

1. DEFINITIONS

1. **'Programme'** means the entire course of study and examinations for the award of a degree.
2. '**Duration of programme**' means the time period required for the conduct of the programme. The duration of a UG degree programme shall be six semesters distributed in a period of 3 years or eight semesters in a period of 4 years.
3. '**Academic Week'** is a unit of five working days in which distribution of work is organized from day one to day five, with five contact hours of one hour duration on each day. A sequence of 18 such academic weeks constitutes a semester.
4. '**Semester**' means a term consisting of 18 weeks (16 instructional weeks and two weeks for examination).
5. '**Course**' means a segment of subject matter to be covered in a semester.
6. '**Common course**' means a course that comes under the category of courses, including compulsory English and additional language courses and a set of general courses applicable for Language Reduced Pattern (LRP) programmes, the selection of which is compulsory for all students undergoing UG programmes.
7. '**Core course**' means a compulsory course in a subject related to a particular degree programme.
8. '**Open course**' means a course which can be opted by a student at his/her choice.
9. **'Improvement course**' is a course registered by a student for improving his/her performance in that particular course.
10. '**Ability Enhancement course/Audit course**' is a course which is mandatory as per the directions from the Regulatory authorities like UGC, Supreme Court etc.
11. '**Department**' means any Teaching Department in a college offering a course of study approved by the University as per the Statutes and Act of the University.
12. '**Department Co-ordinator**' is a teacher nominated by a Dept. Council to co-ordinate all the works related to CBCSSUG undertaken in that department including continuous evaluation.
13. **'Department Council**' means the body of all teachers of a department in a college.
14. '**Parent Department**' means the Department which offers a particular degree programme. The parent department shall be either mathematics or economics which offer core papers in this programme.
15. '**College Co-coordinator**' is a teacher nominated by the college council to co-ordinate the effective running of the process of CBCSS including internal evaluation undertaken by various departments within the college. She/he shall be the convenor for the College

level monitoring committee.

16. '**College level monitoring committee'.** A monitoring Committee is to be constituted for CBCSS UG at the college level with Principal as Chairperson, college co-ordinator as convenor and department co-ordinators as members. The elected College union chair person shall be a member of this committee.

17. '**Faculty Adviser**' means a teacher from the parent department nominated by the Department Council, who will advise the student in the academic matters and in the choice of open courses.

18. '**Credit**'**(C)** is a unit of academic input measured in terms of weekly contact hours/course contents assigned to a course.

19. '**Extra Credit**' is the additional credit awarded to a student over and above the minimum credits required in a programme, for achievements in co-curricular activities and social activities conducted outside the regular class hours, as decided by the University. For calculating CGPA, extra credits will not be considered.

20. '**Letter Grade**' or simply 'Grade' in a course is a letter symbol (O,A+, A,B+, B, C, P, F, I and Ab). Grade shall mean the prescribed alphabetical grade awarded to a student based on his/her performance in various examinations. The Letter grade that corresponds to a range of CGPA is given in Annexure-I.

21. Each letter grade is assigned a '**Grade Point**' **(G)** which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course. **Grade Point** means point given to a letter grade on 10 point scale.

22. '**Semester Grade Point Average' (SGPA)** is the value obtained by dividing the sum of credit points obtained by a student in the various courses taken in a semester by the total number of credits in that semester. SGPA shall be rounded off to three decimal places. SGPA determines the overall performance of a student at the end of a semester.

23. '**Credit Point**'**(P)**of a course is the value obtained by multiplying the grade point (G) by the credit (C) of the course: P=G x C

24. '**Cumulative Grade Point Average**' **(CGPA)** is the value obtained by dividing the sum of credit points in all the semesters taken by the student for the entire programme by the total number of credits in the entire programme and shall be rounded off to three decimal places.

25. **Grade Card** means the printed record of students' performance, awarded to him/her.

26. **Course teacher:** A teacher nominated by the Head of the Department shall be in charge of a particular course.

27. '**Dual core'** means a programme with double core subjects, traditionally known as double main.

28. **'Strike off the roll' A s**tudent who is continuously absent for 14 days without sufficient reason and proper intimation to the Principal of the college shall be removed from the roll.

Words and expressions used and not defined in the regulation, but defined in the Calicut University Act and Statutes shall have the meaning assigned to them in the Act and Statutes.

2. PROGRAMME STRUCTURE

Duration: The duration of a UG Programme shall be 6 semesters distributed over a period of 3 academic years. The odd semesters (1, 3, 5) shall be from June to October and the even semesters (2, 4, 6) shall be from November to March.

Courses: The UG programme shall include five types of courses, viz; Common Courses (Code A), Core courses (Code B), Open Course (Code D), Elective courses (Code E) and Audit courses (Code F).

Course code : Each course shall have a unique alphanumeric code number, which includes Letter G representing syllabus revision 2019, abbreviation of the subject in three letters, the semester number (1 to 6) in which the course is offered, the code of the course (A to F) and the serial number of the course (01, 02 ……) last digit T for theory, P for practical, D for dissertation/project/Field study/Tour report, V for Viva-Voce and F for Audit Course. Core courses and courses in a particular complementary will be numbered continuously

Common Courses: In general, every UG student shall undergo 10 common courses (total 38 credits) chosen from a group of 14 common courses listed below, for completing the programme

A01. Common English Course 1	English courses A01-A06 applicable to BA/BSC Regular pattern
A02. Common English Course II *A03. Common English Course III* *A04. Common English Course IV* *A05. Common English Course V* *A06. Common English Course VI*	English courses A01-A04 applicable to Language Reduced Pattern (LRP) Programmes B.com, BBA, BBA (T), BBM, B.Sc (LRP), BCA etc.
A07. Additional Language Course I *A08. Additional Language Course II* *A09. Additional Language Course III* *A10. Additional Language Course IV*	Addl.Language courses A07-A10 applicable to BA/B.Sc Regular Pattern Addl.Language courses A07-A08 applicable to Language Reduced Pattern (LRP) Programmes
A11. General Course I *A12. General Course II* *A13. General Course III* *A14. General Course IV*	Applicable to Language Reduced Pattern (LRP) Programmes

Common courses A01-A06 shall be taught by English teachers and A07-A10 by teachers of additional languages respectively. General courses A11-A14 shall be offered by teachers of departments offering core courses concerned.
General courses I, II, III and IV shall be designed by the group of boards concerned.

Core courses: Core courses are the courses in the major (core) subjects of the degree programme chosen by the student. Core courses are offered by the parent department.

Open courses: There shall be one open course in core subjects in the fifth semester. The open course offered by B.Sc Economics & Mathematics (Double Main) shall be open to all the students in the institution except for the students having Mathematics as Core Course. The students can opt that course from any other department in the institution. Each department can decide the open course from a pool of three courses offered by the College. Total credit allotted for open course is 3 and the hour per week allotted is 3. If there is only one programme in a college, they can choose either language courses or physical education as open course.

Ability Enhancement courses/Audit courses: These are courses which are mandatory for a programme but not counted for the calculation of SGPA or CGPA. There shall be one Audit course each in the first four semesters. These courses are not meant for class room study. The students can attain only pass (Grade P) for these courses. At the end of each semester there shall be examination conducted by the college from a pool of questions (Question Bank) set by the College. The students can also attain these credits through online courses like SWAYAM, MOOC etc (optional). The list of courses in each semester with credits are given below.

Course with credit	Semester
Environment Studies – 4	1
Disaster Management - 4	2
*Human Rights/Intellectual Property Rights/ Consumer Protection - 4	3
*Gender Studies/Gerontology- 4	4

* College can opt any one of the courses.

Extra credit Activities: Extra credits are mandatory for the programme. Extra credits will be awarded to students who participate in activities like NCC, NSS and Swatch Bharath. Those students who could not join in any of the above activities have to undergo Social Service Programme (SSP). Extra credits are not counted for SGPA or CGPA.

Credits: A student is required to acquire a minimum of 140 credits for the completion of the UG programme, of which 120 credits are to be acquired from class room study and shall only be counted for SGPA and CGPA. Out of the120 credits, 38 (22 for common English courses and 16 for common languages other than English) credits shall be from common courses, 2 credits for project/ corresponding paper and 3 credits for the open course. The maximum credits for a course shall not exceed 5. Dual core programmes are having separate credit distribution. Audit courses shall have 4 credits per course and a total

of 16 credits in the entire programme. The maximum credit acquired under extra credit shall be 4. If more Extra credit activities are done by a student that may be mentioned in the Grade card. The credits of audited courses or extra credits are not counted for SGPA or CGPA.

Attendance: A student shall be permitted to appear for the semester examination, only if he/ she secures not less than75% attendance in each semester. Attendance shall be maintained by the Department concerned. Condonation of shortage of attendance to a maximum of 10% in the case of single condonation and 20% in the case of double condonation in a semester shall be granted by University remitting the required fee. Benefits ofattendance may be granted to students who attend the approved activities of the college /university with the prior concurrence of the Head of the institution. Participation in such activities may be treated as presence in lieu of their absence on production of participation/attendance certificate (within two weeks) in curricular/extracurricular activities (maximum 9 days in a semester). Students can avail of condonation of shortage of attendance in a maximum of four semesters during the entire programme (Either four single condonations or one double condonation and two single condonation during the entire programme). If a student fails to get 65% attendance, he/she can move to the next semester only if he/she acquires 50% attendance. In that case, a **provisional registration** is needed. Such students can appear for supplementary examination for such semesters after the completion of the programme. Less than 50% attendance requires Readmission. Readmission is permitted only once during the entire programme.

Grace Marks: Grace Marks may be awarded to a student for meritorious achievements in co-curricular activities (in Sports/Arts/NSS/NCC/Student Entrepreneurship) carried out besides the regular hours. Such a benefit is applicable and limited to a maximum of 8 courses in an academic year spreading over two semesters. In addition, maximum of 6 marks per semester can be awarded to the students of UG Programmes, for participating in the College Fitness Education Programme (COFE).

Project: Every student of a UG degree programme shall have to work on a project of 3 credits under the supervision of a faculty member or shall write a theory course based on Research Methodology as per the curriculum. College shall have the liberty to choose either of the above. The Project work for B.Sc Mathematical Science is offered by The Department of Economics

3. ADMISSION

The admission to the programme will be as per Rules and Regulations of the University. The eligibility criteria for admission shall be as announced by the University from time to time. Separate rank lists shall be drawn up for reserved seats as per the existing rules.

The admitted candidates shall subsequently undergo the course of study in the college for six semesters within a period of not less than three years; clear all the examinations prescribed and fulfill all such conditions as prescribed by the University from time to time. The college shall make available to all students admitted a prospectus listing all the courses offered in various departments during a particular semester. The information so provided shall contain title of the courses, the semester in which it is offered and credits for the courses. Detailed syllabi shall be made available in the College website.

There shall be a uniform calendar prepared by the College for the registration, conduct/schedule of the courses, examinations and publication of results. The College shall ensure that the calendar is strictly followed.

There shall be provision for Inter Collegiate and Inter University Transfer in third and fifth semester within a period of two weeks from the date of commencement of the semester. College transfer may be permitted in Second and Fourth semester also without change in complementary course within a period of two weeks from the date of commencement of the semester concerned.

Complementary change at the time of college transfer is permitted in the third semester if all conditions are fulfilled.

4. EVALUATION AND GRADING

Mark system is followed instead of direct grading for each question. For each course in the semester letter grade and grade point are introduced in 10 -point indirect grading system as per guidelines given in Annexure-1

Course Evaluation

The evaluation scheme for each course shall contain two parts

1) Internal assessment 2) External Evaluation

20% weight shall be given to the internal assessment. The remaining 80% weight shall be for the external evaluation.

Internal Assessment

20% of the total marks in each course are for internal examinations.

The internal assessment shall be based on a predetermined transparent system involving written tests, Class room participation based on attendance in respect of theory courses and lab involvement/records attendance in respect of Practical Courses.

Internal assessment of the project will be based on its content, method of presentation, final conclusion and orientation to research aptitude.

Components with percentage of marks of Internal Evaluation of Theory Courses are- Test paper 40%, Assignment 20%, Seminar 20% and Class room participation based on attendance 20%.

For the test paper marks, at least one test paper should be conducted. If more test papers are conducted, the mark of the best one should be taken.

To ensure transparency of the evaluation process, the internal assessment marks awarded to the students in each course in a semester shall be notified on the notice board atleast one week before the commencement of external examination. There shall not be any chance for improvement for internal marks.

The Split up of marks for Test paper and Class Room Participation (CRP) for internal evaluation are as follows.

Split up of of marks for Test paper

Range of Marks in Test Paper	Out of 8 (Maximum internal Marks is 20)	Out of 6 (Maximum internal marks is 15)
Less than 35%	1	1
35%- 45%	2	2
45% - 55%	3	3
55% - 65%	4	4
65% -85%	6	5
85% -100%	8	6

Split up of of marks for Class Room Participation

Range of CRP	Out of 4 (Maximum Internal marks is 20)	Out of 3 (Maximum internal marks is 15)
50% ≤CRP <75%	1	1
75% ≤CRP <85%	2	2
85 % and above	4	3

External Evaluation

External evaluation carries 80% of marks. The external question papers may be of uniform pattern with 80/60 marks. The courses with 2/3 credits will have an external examination of 2 hours duration with 60 marks and courses with 4/5 credits will have an external examination of 2.5 hours duration with 80 marks.

The external examination in theory courses is to be conducted by the University with question papers set by external experts. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external examination in

practical courses shall be conducted by two examiners–one internal and an external, the latter appointed by the COE of the college. The project evaluation with viva can be

conducted either internal or external which may be decided by the Board of Studies concerned.

After the external evaluation only marks are to be entered in the answer scripts.

Revaluation: In the new system of grading, revaluation is permissible. The prevailing rules of revaluation are applicable to SJCBCSSUG2019.

Students can apply for photocopies of answer scripts of external examinations. Applications for photocopies/scrutiny/revaluation should be submitted within 10 days of publication of results. The fee for this shall be as decided by the University.

5. INDIRECT GRADING SYSTEM

Indirect grading System based on a 10-point scale is used to evaluate the performance of students. Each course is evaluated by assigning marks with a letter grade (O,A+, A,B+, B, C, P, F, I or Ab) to that course by the method of indirect grading. (See Annexure).

An aggregate of P grade (after external and internal put together) is required in each course for a pass and also for awarding a degree (A minimum of 20% marks in external evaluation is needed for a pass in a course. But no separate pass minimum is needed for internal evaluation). No separate grade/ mark for internal and external will be displayed in the grade card; only an aggregate grade will be displayed. Also the aggregate mark of internal and external is not displayed in the grade card.

A student who fails to secure a minimum grade for a pass in a course is permitted to write the examination along with the next batch.

After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below. For the successful completion of a semester, a student should pass all courses. However, a student is permitted to move to the next semester irrespective of SGPA obtained.

SGPA of the student in that semester is calculated using the formula

$$\text{SGPA} = \frac{\textit{Sum of the credit points of all courses in a semester}}{\textit{Total credits in that semester}}$$

The Cumulative Grade Point Average (CGPA) of the student is calculated at the end of a programme. The CGPA of a student determines the overall academic level of the student in a programme and is the criterion for ranking the students. CGPA can be calculated by the following formula.

$$\text{CGPA} = \frac{\textit{Total credit points obtained in six semesters}}{\textit{Total credits acquired (120)}}$$

SGPA and CGPA shall be rounded off to three decimal places. CGPA determines the broad academic level of the student in a programme and is the index for ranking students (in terms of grade points). An overall letter grade (cumulative grade) for the entire programme shall be awarded to a student depending on her/his CGPA(Annexure-I)

6. METHOD OF INDIRECT GRADING

Evaluation (both internal and external) is carried out using Mark system. The Grade on the basis of total internal and external marks will be indicated for each course, for each semester and for the entire programme.

Indirect Grading System in 10 -point scale is as below:

ANNEXURE I

Ten Point Indirect Grading System

Percentage of Marks (Both Internal & External put together)	Grade	Interpretation	Grade point Average (G)	Range of grade points	Class
95 and above	O	Outstanding	10	9.5 -10	First Classwith Distinction
85 to below 95	A+	Excellent	9	8.5 -9.49	
75 to below 85	A	Very good	8	7.5 -8.49	
65 to below 75	B+	Good	7	6.5 -7.49	First Class
55 to below 65	B	Satisfactory	6	5.5 -6.49	
45 to below 55	C	Average	5	4.5 -5.49	Second Class
35 to below 45	P	Pass	4	3.5 -4.49	ThirdClass
Below 35	F	Failure	0	0	Fail
Incomplete	I	Incomplete	0	0	Fail
Absent	Ab	Absent	0	0	Fail

Example–1 SGPA Calculation

Semester I Course Code	CourseName	Grade Obtained	Grade point (G)	Credit(C)	Creditpoint (CXG)
xxxxxxx	Xxxxxxx	A	8	4	32
xxxxxxx	Xxxxxxxxxx	C	5	3	15
xxxxxxx	Xxxxxxxxxx	A+	9	4	36
xxxxxxx	Xxxxxxxxxx	B+	7	3	21
xxxxxxx	Xxxxxxxxx	P	4	3	12
xxxxxxx	Xxxxxxxxx	C	5	4	20

SGPA = Sum of the Credit points of all courses in a semester
Total Credits in that semester

$$\text{SGPA} = \frac{32+15+36+21+12+20}{21} = \frac{136}{21}$$

SGPA = 6.476

Percentage of marks of semester I = (SGPA/10) x 100 = 64.76 %

Note: The SGPA is corrected to three decimal points and the percentage of marks shall be approximated to two decimal points.

Example: 2

Semester II Course Code	CourseName	Grade Obtained	Grade point (G)	Credit(C)	Credit Point (CxG)
xxxxxx	Xxxxxxx	A	8	4	32
xxxxxxx	Xxxxxxxxxx	C	5	3	15
xxxxxxx	Xxxxxxxxxx	A+	9	4	36
xxxxxxx	Xxxxxxxxxx	B+	7	3	21
xxxxxx*	Xxxxxxxxx	F	0	3	0
xxxxxxx	Xxxxxxxxx	C	5	4	20

*Failed course

Note: In the event a candidate failing to secure 'P' Grade in any Course in a semester, consolidation of SGPA and CGPA will be made only after obtaining **'P'** grade in the failed Course in the subsequent appearance.

CGPA Calculation

$$CGPA = \frac{Total\ Credit\ Points\ Obtained\ in\ Six\ Semesters}{Total\ Credits\ Acquired}$$

$$CGPA = \frac{16 + 145 + 161 + 148 + 131 + 141}{120} = \frac{862}{120}$$

$$CGPA = 7.183$$

$$\text{Total Percentage of Mark} = \frac{CGPA}{10} * 100 = \frac{7.183}{10} * 100 = 71.83$$

$$\boldsymbol{CGPA\ of\ Core\ Courses} = \frac{\boldsymbol{Total\ Credit\ Points\ Obtained\ for\ Core\ Courses}}{\boldsymbol{Total\ Credits\ Acquired\ by\ Core\ Courses}}$$

Similarly CGPA of Complementary Courses, Open Courses, English Common Courses and Additional Language Common Courses may be calculated and the respective percentage may be calculated. All these must be recorded in the Final Grade Card.

ANNEXURE II
Guidelines for the Evaluation of Projects

1. PROJECT EVALUATION- Regular

1. Evaluation of the Project Report shall be done under Mark System.

2. The evaluation of the project will be done at two stages :

    a) Internal Assessment (supervising teachers will assess the project and award internal Marks)

    b) External evaluation (external examiner appointed by the College)

    c) Grade for the project will be awarded to candidates, combining the internal and external marks.

3. The internal to external components is to be taken in the ratio 1:4. Assessment of

    - Internal and External assessment are to be done based on the components given below

Internal (20% of total) Components	**Percentage of marks**	**External (80% of Total) Components**
Originality	20	Relevance of the Topic, Statement of Objectives
Methodology	20	Reference/ Bibliography, Presentation, quality of Analysis/ Use of Statistical Tools.
Scheme/ Organisation of Report	30	Findings and recommendations
Viva – Voce	30	Viva – Voce

4. External Examiners will be appointed by the College from the list of VI Semester Board of Examiners in consultation with the Chairperson of the Board.

5. The Chairman of the VI semester examination board should form the evaluation teams and coordinate their work.

6. Internal Assessment should be completed 2 weeks before the last working day of VI Semester.

7. Internal Assessment marks should be published in the Department Notice Board.

8. In the case of Courses with practical examination, project evaluation shall be done along with practical examinations.

9. The Chairman Board of Examinations, may at his discretion, on urgent requirements, make certain exception in the guidelines for the smooth conduct of the evaluation of project.

PASS CONDITIONS

Submission of the Project Report and presence of the student for viva are compulsory for internal evaluation. No marks shall be awarded to a candidate if she/he fails to submit the Project Report for external evaluation. The student should get a minimum P Grade in aggregate of External and Internal. There shall be no improvement chance for the Marks obtained in the Project Report.

* In the extent of student failing to obtain a minimum of Pass Grade, the project work may be re-done and a new internal mark may be submitted by the Parent Department. External examination may be conducted along with the subsequent batch.

ANNEXURE-III

Question paper type 1Scheme of Examinations:

The external QP with 80 marks and internal examination is of 20marks. Duration of each external examination is 2.5 Hrs. The pattern of External Examination is as given below. The students can answer all the questions in Sections A&B. But there shall be Ceiling in each section.

Section A

Short answer type carries 2 marks each-15 questions	Ceiling -25

Section B

Paragraph/Problem type carries 5 marks each-8 questions	Ceiling -35

Section C

Essay type carries10 marks (2 out of 4)	2X10=20

Question paper type 2Scheme of Examinations:

The external QP with 60 marks and Internal examination is of 15marks. Duration of each external examination is 2 Hrs. The pattern of External Examination is as given below. The students can answer all the questions in Sections A&B. But there shall be Ceiling in each section.

Section A

Short answer type carries 2 marks each-12 questions	Ceiling -20

Section B

Paragraph/Problem type carries 5 marks each-7 questions	Ceiling -30

Section C

Essay type carries 10 marks (1 out of 2)	1X10=10

DISTRIBUTION OF HOURS/ WEEK & CREDIT OF CORE COURSES

Pattern II (Dual Core)			
Semester	**Course**	**Hours/ Week**	**Credit**
I	Introductory Economics	6	4
	Basic calculus	6	4
II	Micro economics I	6	4
	Advanced calculus	6	4
III	Macroeconomics I	5	4
	Basic Logic, Boolean Algebra & Graph Theory	5	4
	Linear programming and probability	4	4
	Financial Economics	6	4
	Multivariable calculus	5	4
IV	Indian Economy	5	4
	Theory of Equations and Complex Numbers	5	4
	Micro economics II	6	4
	Abstract Algebra	5	4
	Distribution theory	4	4
V	Macroeconomics II	4	4
	Econometrics I	4	3
	Project work Economics Mathematics	1 1	-
	Linear algebra	4	3
	Real analysis	4	3
	Statistical inference	4	4
VI	Econometrics II	5	3
	International Economics	4	3
	Computer oriented statistical methods	4	4
	Project work Economics Mathematics	1 1	3
	Numerical analysis	5	5
	Elective (Mathematics)	5	4

DETAILED BREAK UP OF COURSES IS PRESENTED IN FOLLOWING TABLE

First Semester

Course	Course Code	Title of the Course	Hours per week	Credits
Common English			4	3
Common English			5	4
Addl. Language			4	4
Core Course A Economics	GDEC1B01T	Introductory Economics	6	4
Core Course B Mathematics	GDMT1B01T	Basic calculus	6	4
Total			**25**	**19**

Second Semester

Course	Course Code	Title of the Course	Hours per week	Credits
Common English			4	3
Common English			5	4
Addl. Language			4	4
Core Course A Economics	GDEC2B02T	Micro Economics I.	6	4
Core Course B Mathematics	GDMT2B02T	Advanced Calculus	6	4
Total			**25**	**19**

Third Semester

Course	Course Code	Title of the Course	Hours per week	Credits
General Course A Economics	GDEC3A01T	Macroeconomics I	5	4
General Course B Mathematics	GDMT3A01T	Basic Logic, Boolean Algebra & Graph Theory	5	4
Core Course A Economics	GDEC3B03T	Linear Programming and probability	4	4
Core Course A Economics	GDEC3B04T	Financial Economics	6	4
Core Course B Mathematics	GDMT3B03T	Multivariable calculus	5	4
Total			**25**	**20**

Fourth Semester

Course	Course Code	Title of the Course	Hours per week	Credits
General Course A Economics	GDEC4A02T	Indian Economy	5	4
General Course B Mathematics	GDMT4A02T	Theory of Equations and Complex Numbers	5	4
Core Course A Economics	GDEC4B05T	Micro Economics II	6	4
Core Course B Mathematics	GDMT4B04T	Abstract Algebra	5	4
Core Course B Mathematics	GDMT4B05T	Distribution theory	4	4
Total			**25**	**20**

Fifth Semester

Course	Course Code	Title of the Course	Hours per week	Credits
Core Course A Economics	GDEC5B06T	Macroeconomics II	4	4
Core Course A Economics	GDEC5B07T	Econometrics I	4	3
Core Course B Mathematics	GDMT5B06T	Linear Algebra	4	3
Core Course B Mathematics	GDMT5B07T	Real Analysis	4	3
Core Course B Mathematics	GDMT5B08T	Statistical Inference	4	4
Open Course (Mathematics)		Open Course	3	3
Project Work	GDEC6B11D GDMT6B10D	Economics Mathematics	1 1	-
Total			**25**	**20**

Sixth Semester

Course	Course Code	Title of the Course	Hours per week	Credits
Core Course A Economics	GDEC6B08T	Econometrics II	5	3
Core Course A Economics	GDEC6B09T	International Economics	4	3
Core Course A Economics	GDEC6B10P	Computer oriented statistical methods	4	4
Core Course B Mathematics	GDMT6B09T	Numerical Analysis	5	5
Elective CoreCourse	GDMT6EXXX	Mathematics(Elective)	5	4
Project Work	GDEC6B11D GDMT6B10D	Economics Mathematics	1 1	3
Total			**25**	**22**

Programme Specific Outcome

PSOs	PROGRAMME SPECIFIC OUTCOMES
PSO1	Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an undergraduate programme of study
PSO2	Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
PSO3	Ability to use mathematics as a precise language of communication in other branches of human knowledge.
PSO4	Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization
PSO5	Ability to employ critical thinking in understanding the concepts in every area of mathematics
PSO6	Ability to analyse the results and apply them in various problems appearing in different branches of mathematics
PSO7	Capability to solve problems using concepts of linear algebra.
PSO8	Capability to solve various models such as growth and decay models, radioactive decay model, LCR circuits and population models using techniques of differential equations.
PSO9	Ability to solve linear system of equations, linear programming problems and network flow problems.
PSO10	Ability to provide new solutions using the domain knowledge of mathematics acquired during this programme
PSO11	Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
PSO12	To know about the advances in various branches of mathematics
PSO13	Capability to use appropriate software to solve system of equations and differential equations
PSO14	Ability to work independently and do in-depth study of various notions of mathematics
PSO15	Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning
PSO16	Ability to apply the acquired knowledge in all aspects
PSO17	Experimental skills
PSO18	Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects
PSO19	The design of the programme is intended to understand a comprehensive view of the subject matter of economics.
PSO20	The diversity of courses included in the programme makes the student understand the diverse nature of economic theories.
PSO21	The Introduction of more quantitative course will help the student to acquire the fundamentals of economic model building.
PSO22	A blending of the financial and public economics with core courses makes the student to face the real life situations of banking, share markets, budgetary practices etc.
PSO23	To imbibe the student a new vision in economic studies by creating research content in every course.
PSO24	The proposed project report in the syllabus will inculcate the students a practice of real research.
PSO25	Students shall attain a strong foundation of mathematics so that they will be able to solve complicated problems in Economics
PSO26	The programme will produce good Economists with a sound mathematical background

FIRST SEMESTER
GDEC1B01T: INTRODUCTORY ECONOMICS

Lecture Hours: 96 (6 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	To understand the basic concepts of Microeconomics.
CO2	To familiarize with the demand and supply aspects so that students will be able to determine equilibrium
CO3	To understand consumer and producer behaviour.
CO4	To understand the basic concepts of cost and revenue and Market.
CO5	To understand basic concepts of macroeconomics like national income, inflation and unemployment

Module 1. Subject matter of Economics (6 Hrs)
Why study economics? Scope and method of economics - The economic problem: Scarcity and choice . How economists explain. Economic models and the role of assumptions.
Circular flow, production possibility curve.

Module II Supply and Demand: How Markets Work, Markets and Welfare (20 Hrs)
Elementary theory of demand – determinants of household demand and market demand, andshifts in the demand curves. Elasticity of demand
Elementary theory of supply - factors influencing supply, derivation of the supply curve, andshifts in the supply curve. Determination of equilibrium price in a competitive market.
Consumer surplus, producer surplus and the efficiency of the markets.

Module III Consumer Behavior (10 Hrs)
The consumption decision – description of preferences (representing preferences with indifference curves) - properties of indifference curves; budget constraint; optimum choice.

Module IV Production, Cost and Revenue: (14 Hrs)
Short run and long run production function – Law of variable Proportions and isoquant. Cost function- Costs in the short run and long run
- Revenue Function

Module V The Firm and Market Structure: (8 Hrs)
Perfect competition, monopoly, monopolisticcompetition and oligopoly

Module VI Introduction to Macroeconomics and National Income Accounting: (12 Hrs)
Introduction to Macroeconomic variables; microeconomic and macroeconomic approaches; basic issues studied in macroeconomics; measurement of GDP, GNP, NDP, NNP and NI; circular flow ofincome; problems encountered in measuring National Income; real versus nominal GDP - CPI, WPI and GDP deflator, National Income as a measure of welfare

Module VII Money and financial markets : **(16 Hrs)**
Definitions of money – M1, M2, M3 and M4; Functions of money; determination of money supply. Money multiplier; control of money supply by thecentral bank tools of monetary policy.

Module VIII Inflation and Unemployment (10 Hrs)

Meaning of inflation, cost of inflation and hyper inflation . Money supply and Inflation c. Concepts of unemployment, natural rate of unemployment, structural unemployment, frictional unemployment , cyclical unemployment, involuntary and voluntary unemployment

Readings

1. Joseph E. Stiglitz and Carl E. Walsh, Economics, W.W. Norton & Company, Inc.,New York, International Student Edition, 4th Edition, 2007.
2. N. Gregory Mankiw, Economics: Principles and Applications, India edition by South Western, a part of Cengage Learning, Cengage Learning India Private Limited, 4th edition, 2007.
3. Karl E. Case and Ray C. Fair, Principles of Economics, Pearson Education Inc., 8t
4. Mankiw, N.G., Macroeconomics, Worth Publishers, 7th edition, 2010.
5. Froyen, R.T., Macroeconomics, Pearson Education Asia, 2nd edition, 2005.

FIRST SEMESTER
GDMT1B01T: BASIC CALCULUS

Lecture Hours: 96 (6 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

Aims, Objectives and Outcomes:

The mathematics required for viewing and analyzing the physical world around us is contained in calculus. While Algebra and Geometry provide us very useful tools for expressing the relationship between static quantities, the concepts necessary to explore the relationship between moving/changing objects are provided in calculus. The objective of the course is to introduce students to the fundamental ideas of limit, continuity and differentiability and also to some basic theorems of differential calculus. It is also shown how these ideas can be applied in the problem of sketching of curves and in the solution of some optimization problems of interest in real life.

The topics also deal with the other branch of calculus viz. integral calculus. Historically, it is motivated by the geometric problem of finding out the area of a planar region. The idea of definite integral is defined with the notion of limit. A major result is the Fundamental Theorem of Calculus, which not only gives a practical way of evaluating the definite integral but establishes the close connection between the two branches of Calculus.

The notion of definite integral not only solves the area problem but is useful in finding out the arc length of a plane curve, volume and surface areas of solids and so on. The integral turns out to be a powerful tool in solving problems in physics, chemistry, biology, engineering, economics and other fields. Some of the applications are included in the syllabus.

Using the idea of definite integral, the natural logarithm function is defined and its properties are examined. This allows us to define its inverse function namely the natural exponential function and also the general exponential function. Exponential functions model a wide variety of phenomenon of interest in science, engineering, mathematics and economics. They arise naturally when we model the growth of a biological population, the spread of a disease, the radioactive decay of atoms, and the study of heat transfer problems and so on. We also consider certain combinations of exponential functions namely hyperbolic functions that also arise very frequently in applications such as the study of shapes of cables hanging under their own weight.

COs	**COURSE OUTCOMES**
CO1	At the end of the course students get able to be familiar to the world of calculus and they develop their own way of writing and explaining mathematics
CO2	Students also experience the classical way of doing and enjoying mathematics in a much more logical way

Text :	Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010)* *ISBN: 978-0-534-46579-7*

Module-I **(15hrs)**

1.1 : Intuitive introduction to Limits- A Real-Life Example, Intuitive Definition of a Limit, One-Sided Limits, Using Graphing Utilities to Evaluate Limits

1.2 : Techniques for finding Limits- Computing Limits Using the Laws of Limits, Limits of Polynomial and Rational Functions, Limits of Trigonometric Functions, The Squeeze Theorem.1.3: Precise Definition of a Limit- $\varepsilon - \delta$ definition of limit, A Geometric Interpretation, Some illustrative examples

1.4: Continuous Functions- Continuity at a Number, Continuity at an Endpoint, Continuity on an Interval, Continuity of Composite Functions, Intermediate Value Theorem

2.1: The Derivatives- *Definition* only

2.9: Differentials and Linear Approximations- increments, Differentials, Error Estimates, Linear Approximations, Error in Approximating Δy by dy.

Module-II Text (2) **(25 hrs)**

3.1 : Extrema of Functions -Absolute Extrema of Functions, Relative Extrema of Functions, *Fermat's Theorem***,** Finding the Extreme Values of a Continuous Function on a Closed Interval,An Optimization Problem

3.2 : The Mean Value Theorem- Rolle's Theorem, *The Mean Value Theorem***,** Some Consequences of the Mean Value Theorem, Determining the Number of Zeros of a Function

3.3: Increasing and Decreasing Functions- *definition, inferring the behaviour of function from sign of derivative,* Finding the Relative Extrema of a Function, *first derivative test*

3.4 : Concavity and Inflection points- Concavity, Inflection Points, The Second Derivative Test, The roles of $'$and f'' in determining the Shape of a Graph

3.5 : Limits involving Infinity; Asymptotes- Infinite Limits, Vertical Asymptotes, Limits at Infinity, Horizontal Asymptotes, Infinite Limits at Infinity, Precise Definitions

3.6 : Curve Sketching-The Graph of a Function, Guide to Curve Sketching, Slant Asymptotes, Finding Relative Extrema Using a Graphing Utility

3.7 : Optimization Problems – *guidelines for finding absolute extrema,* Formulating Optimization Problems- *application involving several real life problems*

Module-III Text (2) **(20 hrs)**

4.1: Anti derivatives, Indefinite integrals, Basic Rules of Integration, *a few basic integration formulas and rules of integration,* Differential Equations, Initial Value Problems

4.3 : Area- An Intuitive Look, The Area Problem, Defining the Area of the Region Under the Graph of a Function-*technique of approximation ['Sigma Notation' and 'Summation Formulas' Omitted]* An Intuitive Look at Area (Continued), Defining the Area of the Region Under the Graph of a Function-*precise definition,* Area and Distance

4.4 : The Definite Integral- Definition of the Definite Integral, Geometric Interpretation of the Definite Integral, The Definite Integral and Displacement, Properties of the Definite Integral, More General Definition of the Definite Integral

4.5 : The Fundamental Theorem of Calculus- How Are Differentiation and Integration Related? The Mean Value Theorem for Definite Integrals, The Fundamental Theorem of Calculus: Part I, *inverse relationship between differentiation and integration*, Fundamental Theorem of Calculus: Part 2, Evaluating Definite Integrals Using Substitution, Definite Integrals of Odd and Even Functions, The Definite Integral as a Measure of Net Change.

Module-IV **(15hrs)**

5.1 : Areas between Curves- A Real Life Interpretation, The Area Between Two Curves, Integrating with Respect to -*adapting to the shape of the region*, What Happens When the Curves Intertwine?

5.2 : Volume – Solids of revolution, *Volume by* Disk Method, *Region revolved about the x-axis, Region revolved about the y-axis, Volume by the* Method of Cross Sections *[' Washer Method' omitted]*

5.4: Arc Length and Areas of surfaces of revolution- Definition of Arc Length, Length of a Smooth Curve, *arc length formula*, The Arc Length Function, *arc length differentials*, Surfaces of Revolution, *surface area as surface of revolution*

Module-V **(21 hrs)**

6.1: The Natural logarithmic function- *definition*, The Derivative of $ln\ x$, Laws of Logarithms,The Graph of the Natural Logarithmic Function, The Derivatives of Logarithmic Functions, Logarithmic Differentiation, Integration Involving Logarithmic Functions

6.3 : Exponential Functions- The number *e*, Defining the Natural Exponential Function, *properties*, The Laws of Exponents, The Derivatives of Exponential Functions, Integration of the Natural Exponential Function

6.4 : General Exponential and Logarithmic Functions - Exponential Functions with Base *a*, *lawsof exponents*, The Derivatives of a^x and a^u, , Graphs of $y= a^x$, integrating a^x, Logarithmic Functions with Base *a*, *change of base formula*, The Power Rule (General Form), The Derivatives of Logarithmic Functions with Base *a*, The Definition of the Number *e* as a Limit *['Compound Interest' omitted]*

6.6 : Hyperbolic functions- The Graphs of the Hyperbolic Functions, Hyperbolic Identities, Derivatives and Integrals of Hyperbolic Functions, Inverse Hyperbolic Functions, *representation in terms of logarithmic function*, Derivatives of Inverse Hyperbolic Functions,An Application

6.7 : Indeterminate forms and l'$H^{\wedge}$opital rule- *motivation*, The Indeterminate Forms $\frac{\mathbf{0}}{\mathbf{0}}$ and $\frac{\infty}{\infty}$, The Indeterminate Forms $\infty - \infty$ and $0, \infty$, The Indeterminate forms 0^0, ∞^0 and 1^{∞}.

References:

1	Susanna S Epp: Discrete Mathematics with Applications(4/e) *Brooks/Cole Cengage Learning(2011) ISBN: 978-0-495-39132-6*
2	Kenneth H. Rosen: Discrete Mathematics and Its Applications(7/e) *McGraw-Hill, NY(2007) ISBN: 978-0-07-338309-5*
3	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
4	Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
5	Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) *W. H. Freeman and Company(2015) ISBN: 1319116450*
6	Anton, Bivens & Davis : Calculus *Early Transcendentals* (11/e) *John Wiley & Sons,Inc.(2016) ISBN: 1118883764*
7	James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978-1-285-74062-1*
8	Jerrold Marsden & Alan Weinstein : Calculus I and II (2/e*) Springer Verlag NY (1985)ISBN 0-387-90974-5 : ISBN 0-387-90975-3*

SECOND SEMESTER
GDEC2B02T: MICROECONOMICS - I

Lecture Hours: 96 (6 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	To understand and analyse Consumer and producer behavior with quantitative tools.
CO2	Also it enables students to apply theory in real practical life though optimization principles.

Module I: Markets and Prices: (16 Hrs)
Demand, supply and equilibrium. market demand, elasticity, elasticity and revenue, Comparative static analysis

Module II. Consumer Theory: (40 Hrs)
Consumer preferences, axioms about preferences. Indifference curves, Marginal Rate of Substitution, Different types of preferences, Utility, utility functions. Marginal utility and marginal rate of substitution
Budget constraint, utility maximization and choice, optimal choice. Demand, Normal, inferior and Giffen goods. Revealed preference. Slutsky equation. choice under risk and uncertainty.

Module III: Production and Costs (40 Hrs)
Production function, short run and long run, isoquants, marginal rate of technical substitution, returns to scale, elasticity of substitution Types of production functions. Cost and cost functions, Properties of cost functions, cost minimizing input choice, short run and long run costs.

References:

1. Hal R Varian (2014) - *Intermediate Microeconomics with calculus*, 1st edition, W W Norton and Company
2. Christopher Snyder and Walter Nicholson (2017) - *Microeconomic Theory-Basic Principles and Extensions*, Cengage Learning
3. Dominick Salvatore (2003): Microeconomics: Theory and Applications- 4th Edition, Oxford University Press.
4. Robert S Pindyck and Daniel L Rubinfeld (2009): Microeconomics- 8th Edition, Pearson India.
5. Hal R Varian and Theodore C Bergstrom(2014)- Workouts in intermediate microeconomics (to be used along with *Intermediate Microeconomics with calculus* for problem solving)

SECOND SEMESTER
GDMT2B02T: ADVANCED CALCULUS

Lecture Hours: 96 (6 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

Aims, Objectives and Outcomes

The students are introduced to the idea of *improper integrals*, their convergence and evaluation. This enables to study a related notion of convergence of a *series*, which is practically done by applying several different tests such as integral test, comparison test and soon. As a special case, a study on power series- their region of convergence, differentiation andintegration etc., is also done.

Geometry is, basically, the study concerned with questions of shape, size, and relativeposition of planar and spatial objects. The classical Greek geometry, also known as *Euclideangeometry* after the work of Euclid, was once regarded as one of the highest points of rational thought, contributing to the thinking skills of logic, deductive reasoning and skills in problemsolving.

In the early 17th century, the works of Rene Descartes and Pierre de Fermat put the foundation stones for the creation of *analytic geometry* where the idea of a coordinate system was introduced to simplify the treatment of geometry and to solve a wide variety of geometric problems.

A detailed study of plane and space curves is then taken up. The students get the idea of parametrization of curves; they learn how to calculate the arc length, curvature etc. using parametrization and also the area of surface of revolution of a parametrized plane curve. Students are introduced into other coordinate systems which often simplify the equation of curves and surfaces and the relationship between various coordinate systems are also taught. This enables them to directly calculate the arc length and surface areas of revolution of a curvewhose equation is in polar form. At the end of the course, the students will be able to handle *vectors* in dealing with the problems involving geometry of lines, curves, planes and surfaces in space and have acquired the ability to sketch curves in plane and space given in vector valuedform.

COs	**COURSE OUTCOMES**
CO1	The students get the idea of parametrization of curves; they learn how to calculate the arc length, curvature etc. using parametrization and also the area of surface of revolution of a parametrized plane curve
CO2	Students are introduced into other coordinate systems which often simplify the equation of curves and surfaces and the relationship between various coordinate systems
CO3	Students will be able to handle vectors in dealing with the problems involving geometry of lines, curves, planes and surfaces in space and have acquired the ability to sketch curves in plane and space given in vector valued form

Text	Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010)* *ISBN: 978-0-534-46579-7*

Module-I **(25hrs)**

7.6 : Improper integrals – *definition*, Infinite Intervals of Integration, Improper Integrals with Infinite Discontinuities, A Comparison Test for Improper Integrals

9.1 : Sequences- *definition, recursive definition,* Limit of a Sequence, *limit laws, squeeze theorem*, Bounded Monotonic Sequences, *definition, monotone convergence theorem (only statement; its proof omitted)*

9.2 : Series- *defining the sum, convergence and divergence*, Geometric Series, The Harmonic Series, The Divergence Test, Properties of Convergent Series

9.3 : The Integral Test – investigation of convergence, integral test, The *p* Series, *its convergence and divergence*

9.4 : The Comparison Test- *test series*, The Comparison Test, The Limit Comparison Test

Module-II **(20 hrs)**

9.5 : Alternating Series- *definition, the alternating series test, its proof, examples,* Approximating the Sum of an Alternating Series by S_n.

9.6 : Absolute Convergence- *definition, conditionally convergent*, The Ratio Test, The Root Test, Summary of Tests for Convergence and Divergence of Series, Rearrangement of Series 9.7: Power Series- *definition,* Interval of Convergence, *radius of convergence,* Differentiation and Integration of Power Series

9.8 : Taylor and Maclaurin Series- *definition, Taylor and Maclaurin series of functions,* Techniques for Finding Taylor Series

Module-III **(20 hrs)**

10.2 : Plane Curves and Parametric Equations- Why We Use Parametric Equations, Sketching Curves Defined by Parametric Equations

10.3 : The Calculus of parametric equations- Tangent Lines to Curves Defined by Parametric Equations, Horizontal and Vertical Tangents,

Finding $\frac{d^2y}{dx^2}$ from Parametric Equations, The Length of a Smooth Curve,

The Area of a Surface of Revolution

10.4 : Polar coordinates-The Polar Coordinate System, Relationship between Polar and Rectangular Coordinates, Graphs of Polar Equations, Symmetry, Tangent Lines to Graphs of Polar Equations

10.5 : Areas and Arc Lengths in polar coordinates-Areas in Polar Coordinates, *area bounded by polar curves*, Area Bounded by Two Graphs, Arc Length in Polar Coordinates, Area of a Surface of Revolution, Points of Intersection of Graphs in Polar Coordinates

Module-IV **(14hrs)**

11.5 : Lines and Planes in Space-Equations of Lines in Space, *parametric equation, symmetric equation of a line,* Equations of Planes in Space, *standard equation,* Parallel and Orthogonal Planes, The Angle Between Two Planes, The Distance Between a Point and a Plane

11.6 : Surfaces in Space- Traces, Cylinders, Quadric Surfaces, *Ellipsoids, Hyperboloids of One Sheet, Hyperboloids of Two Sheets, Cones, Paraboloids, Hyperbolic Paraboloids*

11.7 : Cylindrical and Spherical Coordinates-The Cylindrical Coordinate System, *converting cylindrical to rectangular and vice versa,* The Spherical Coordinate System, *converting spherical to rectangular and vice versa*

Module-V **(17 hrs)**

12.1 : Vector Valued functions and Space Curves- *definition of vector function,* Curves Defined by Vector Functions, *['Example 7' omitted]* Limits and Continuity

12.2 : Differentiation and Integration of Vector-Valued Function- The Derivative of a Vector Function, Higher-Order Derivatives, Rules of Differentiation, Integration of Vector Functions,12.3: Arc length and Curvature- Arc Length *of a space curve,* Smooth Curves, Arc LengthParameter, *arc length function,* Curvature, *formula for finding curvature,* Radius of Curvature12.4: Velocity and Acceleration- Velocity, Acceleration, and Speed; Motion of a Projectile 12.5: Tangential and Normal Components of Acceleration- The Unit Normal, *principal unitnormal vector***,** Tangential and Normal Components of Acceleration *[The subsections 'Kepler's Laws of Planetary Motion ', and `Derivation of Kepler's First Law' omitted]*

References:

1	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
2	Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
3	Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) *W. H. Freeman and Company(2015) ISBN: 1319116450*
4	Anton, Bivens & Davis : Calculus *Early Transcendentals* (11/e) *John Wiley & Sons,Inc.(2016) ISBN: 1118883764*
5	James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978-1-285-74062-1*
6	Jerrold Marsden & Alan Weinstein : Calculus I and II (2/e*) Springer Verlag NY (1985)ISBN 0-387-90974-5 : ISBN 0-387-90975-3*

General Course
THIRD SEMESTER
GDEC3A01T: MACROECONOMICS - I

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	Students are expected to learn and explain the theory of income and employment determination
CO2	Students are expected to learn the aggregate demand/aggregate supply model and explain its uses, and limitations

Module I: Basic issues in macroeconomics: **(10 Hrs)**
Major issues in macroeconomics, National income accounting , Basic concepts

Module II: Classical Theory of employment and output determination: (20 Hrs)
Classical theory of employment and output. Classical aggregate supply curve. Money and inflation, social cost of inflation. Quantity theory of money. classical theory of aggregate demand. classical theory of interest rate determination

Module III: Economy in the long run: (10 Hrs)
Solow model of growth- Production function, investment function, capital accumulation and steady state. Dynamics of the model, change in saving rate, population growth. Technological progress. Convergence in the Solow model. Growth empirics. The economics of ideas. Technology. Endogenous growth theory,

Module IV. Keynesian model of income determination (20 Hrs)
Keynes' critique of classical theory. Keynesian model of income determination. Investment multiplier, Fiscal multipliers.
IS LM model. Money supply, money demand and equilibrium in the money market. IS LM model. Policy effects in the IS LM model.

Module V: Labour market and Derivation of Aggregate Supply Curve (10 Hrs)
Labour market analysis. Classical versus Keynesian labour market analysis. Derivation of aggregate supply and aggregate demand curves. Interaction of aggregate and aggregate supplyand equilibrium.

Module VI: Expectation and the economy (10 Hrs)
Inflation, unemployment and expectations. Phillips curve.Expectations augmented Phillipscurve analysis, NAIRU, Adaptive and rational expectations. Policy ineffectiveness debate.

References:

1. N Dornbusch,S Fischer and R Startz (2018)-Macroeconomics,12th edition,McGrawpublishers
2. N. Gregory Mankiw 2018) - Macroeconomics,10th edition, Worth Publishers,
3. Olivier Blanchard (2017) - Macroeconomics, 6th edition, Pearson Education,
4. Richard T. Froyen (2013)- Macroeconomics: Theories and Policies, 10th edition Pearson Education
5. Andrew B. Abel and Ben S. Bernanke (2011)- Macroeconomics, 7th edition, Pearson education
6. Brian Snowdon and Howard Vane (2005) - Modern Macroeconomics, its origin development and current state, 1st edition

THIRD SEMESTER
GDMT3A01T : BASIC LOGIC, BOOLEAN ALGEBRA AND GRAPH THEORY

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	Identify correct and incorrect arguments
CO2	Understand the criteria for the evaluation of arguments
CO3	Understand the scientific way of decision making using the laws of logic
CO4	Understand the concept of algebraic structures in Mathematics
CO5	Identify a given algebraic structure as belonging to a particular family of structures and
CO6	to state the characteristic properties of the members of the family
CO7	Understand the concept of groups and derive basic theorems on groups
CO8	Define the concept of Boolean algebra as an algebraic structure and list its properties
CO9	Understand the applications of Boolean algebra in switching circuits
CO10	Define a Graph and identify different classes of graphs
CO11	Understand various applications of Graph theory

Text (1)	Discrete Mathematics with Applications : Thomas Koshy, Elsever Academic Press (2004), ISBN : 0-12-421180-1
Text (2)	Theory and Problems of Discrete Mathematics : Third Edition, Seymour Lipschutz, Marc Lars Lipson, McGraw-Hill Companies
Text (3)	A First Look at Graph Theory: John Clark & Derek Allan Holton, Allied Publishers, First Indian Reprint 1995

Module – I **Text (1)** **(20 hrs)**

1.1 : Propositions- definition, Boolean (logic) variables, Truth Value, Conjunction, Boolean expression, Disjunction (inclusive and exclusive), Negation, Implication, Converse, Inverse and Contra positive, Biconditional statement, Order of Precedence, Tautology Contradiction and

Contingency ['Switching Networks' omitted]

1.2 : Logical equivalences- laws of logic ['Equivalent Switching Networks' 'Fuzzy logic' & 'Fuzzy decisions'omitted]

1.3 : Quantifiers - universal & existential, predicate logic

1.4 : Arguments - valid and invalid arguments, inference rules

1.5 : Proof Methods – vacuous proof, trivial proof, direct proof, indirect proof-contrapositive & contradiction, proof by cases, Existence proof constructive & non constructive, counterexample

Module –II Text (2) (20 hrs)

Lattices

14.2 Ordered Sets (Kleene Closure and Order omitted)
14.3 Hasse Diagrams of Partially Ordered Sets
14.4 Consistent Enumeration
14.5 Supremum and Infimum
14.6 Isomorphic (Similar) Ordered Sets
14.7 Well- ordered sets
14.8 Lattices
14.9 Bounded Lattices
14.10 Distributive Lattices
14.11 Complements, Complemented Lattices

Module – III Text (3) (20 hrs)

Graph Theory

1.1 Definition of a graph
1.2 Graphs as models
1.3 More definitions
1.4 Vertex degrees
1.5 Sub graphs

1.6 Paths and Cycles
1.7 Matrix representation of a graph [up to Theorem 1.6 ; proof of Theorem 1.5 is omitted]
2.1 Definitions and Simple Properties
2.2 Bridges [Proof of Theorem 2.6 and Theorem 2.9 are omitted]

Module – IV Text (3) (20 hrs)

2.3 Spanning Trees
2.6 Cut Vertices and Connectivity [Proof of Theorem 2.21 omitted]
3.1 Euler Tour [up to Theorem 3.2, proof of Theorem 3.2 omitted]
3.3 Hamiltonian Graphs [Proof of Theorem 3.6 omitted]
5.1 Plane and Planar graphs [Proof of Theorem 5.1 omitted]
5.2 Euler's Formula [Proofs of Theorems 5.3 and Theorem 5.6 omitted]

References:

1. Susanna S Epp : Discrete Mathematics with Applications (4/e), Brooks/Cole Cengage Learning (2011), ISBN : 978-0-495-39132-6
2. Kenneth H. Rosen : Discrete Mathematics and Its Applications (7/e), McGraw-Hill, NY(2007), ISBN : 978-0-07-338309-5

3. R.J. Wilson: Introduction to Graph Theory, 4th ed., LPE, Pearson Education
4. J.A. Bondy & U.S.R. Murty : Graph Theory with Applications
5. J. Clark & D.A. Holton: A First Look at Graph Theory, Allied Publishers
6. N. Deo : Graph Theory with Application to Engineers

THIRD SEMESTER
GDEC3B03T: LINEAR PROGRAMMING AND PROBABILITY

Lecture Hours: 64 (4 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	To formulate a given simplified description of a suitable real world problem as a linear programming model in general form
CO2	To solve a linear programming problem using various methods
CO3	To understand various approaches to probability and compute probabilities

Module I: **(16 Hrs)**
Formulation of linear programming problem(LPP), Graphical solution, Convex sets, Convex polyhedron, Hyper planes, Slack and surplus variables, Extreme point and basic feasible solution of an LPP, Simplex method, Artificial variables, Big M-Method and Two phase Simplex method, Multiple and unbounded solution to an LPP, Revised Simplex method.

Module II: **(16 Hrs)**
Dual of an LPP, Weak duality theorem, Fundamental theorem of duality, Dual simplex method, Post optimality (Sensitivity) analysis, Integer programming problem - Geometry's cutting plane method and Branch and bound method.

Module III: **(16 Hrs)**
Transportation problem - Balanced an unbalanced TP, Loop in a TP, Obtaining initial basic feasible solution. Transportation algorithm for obtaining optimal solution, Assignment problem, Game theory - Two-person zero Sum game, Pure and mixed strategies, Graphical solution to an mx2 and 2xn game, Game and LPP, Fundamental theorem of game.

Module IV: **(16 Hrs)**
Different approaches to probability. Axioms of probability, Combinatorial methods for evaluating probabilities, Conditional probability and independence. Addition and multiplication theorem, Law of total probability and Bayes theorem

References:

1. Michael J Evans and Jeffrey S. Rosenthal, Probability and statistics: The Science of uncertainty University of Toronto (Book pdf)
2. Kanti Swaroop. P.K Gupta and Manmohan (2010)Operations Research, Sultan Chand and Sons.
3. Saeed Ghahramani (2012), Fundamentals of probability with Stochastic process.Pearson
4. Hogg and Tanis (2002), Probability and statistical inference

THIRD SEMESTER
GDEC3B04T:FINANCIAL ECONOMICS

Lecture Hours: 96 (6 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	After completing this course, the student will be able to develop comprehensive knowledge on the role of finance in the operation of an economy
CO2	Enables them to know the operation of the Indian Financial System and activities in the financial markets

Module -1 Introduction to Banking System (20 Hrs)
Brief history of banking - Unit banking - Branch banking - Mixed banking - Commercial banks - Central bank - Development banks (IFCI, IDBI, SFC) - Recent trends in banking – (e-banking - Internet banking - Debit card - Credit card, ATM, EFTS - RTGS - Tele banking - E - Purse. *Concepts only*) - Banking ombudsman - Banking sector reforms.

Module -2 Insurance (20 Hrs)
Definition, Evolution, Principle, kinds - Types of insurance - Risk and uncertainty – need for security against economic difficulties - Risk management process – Kinds of Life insurancePolicies- (Term insurance - Whole life - Endowment – Annuities) Motor insurance Policies - Kinds of policies - Conditions - Settlement of claims – Insurance company operations in India (LIC, GIC, IRDA)

Module -3 Introduction to financial system & financial markets (20 Hrs)
Financial system – structure – functions – financial markets
Money Market: Functions – instruments (Call loans, Collateral loans, promissory notes, bills of exchange, treasury bill, certificate of deposit, commercial paper *Concepts only*) – acceptance market – discount houses
Capital Market: Functions – Structure – Instruments (Preference shares, Equity shares, Debentures or Bonds, Government securities, Euro Issues. *Concepts only*) – Capital Market Institutions (DIIs, FIIs, Mutual Funds)

Module -4 Primary & Secondary Markets In Capital Market (20 Hrs)
Primary Market (New issue market) : Functions – Intermediaries (Merchant Bankers/Lead Managers, Registrars to an Issus, Underwriters, Bankers to an Issue, Brokers to an Issue, Debenture Trustees. *Concepts only*) - Methods of Floating New Issues (Pure Prospectus method, Private Placement Method, IPO Method, Rights Issue Method, Bonus Issue Method, Book Building Method, Employee Stock Option (ESOP) *Concepts only*)
Secondary Market (Stock Exchanges) : Difference between Primary market and Secondary Market – Nature & functions of stock exchanges - Listing of Securities – Settlement & trading in stock exchange – players in stock exchanges (Speculators – Bulls, Bears, Lame Duck, Stag. *Concepts only*) – Kerb trading – Insider training

Module -5 Indian Financial System (16 Hrs)
Features of Indian Money Market – DFHI & RBI in Indian money market
Origin and development of stock exchanges in India (BSE, NSE, OTCEI, SEBI) - Stock market index in India & abroad (SENSEX, NIFTY, NASDAQ, Dow Jones, FTSE, NIKKEI,ISE. *Concepts only*) – Depositories in India (NSDL, CSDL) – Credit rating agencies in India (CRISIL, ICRI, CARE).

Assignment (Internship): Students may be directed to study the share holding patternof any one share company in their domicile

References:

1. K.P.M. Sundaram and E.N.Sundaram - Modem Banking - Sulthan Chand and sons -New Delhi.
2. Sekhar and Sekhar - Banking and financial system - Margham publication - Chennai.
3. K.C. Mishra and Mangala Bakshi (2009), Insurance Business Environment and Insurance Company Operations, National Insurance Academy | Cengage Learning,New Delhi.
4. Dr. V.Balu - Banking and financial system Sri. Venkiteswarapublications - Chennai.
5. 5.Rejda, Principles of Risk Management and Insurance, 9thEdition,PearsonEducation.
6. Mishra.M.N - Insurance, Principles and practices - Sulthanchand and company New Delhi.
7. Guptha.O.S - Life Insurance - Frank Brothers - New Delhi.
8. Pamda.G.S. - Principles and practise of insurance - Kalyani publishers - New Delhi.
9. Gordan K. Natarajan , "Financial Markets and Services", Himalaya Publishing House, Mumbai (Latest Edition).
10. S. Gurusamy, 'Capital Markets', Vijay Nicole Imprints Private Limited, Chennai (Latest edition)
11. M.Y. Khan, 'Indian Financial System', Tata McGraw Hill Education Private Limited, New Delhi (Recent edition)
12. L.M. Bhole, 'Financial Institutions and Markets-Structure, Growth and Innovations', Tata McGraw Hill Publishing Company Limited, New Delhi (Latestedition)
13. Bharathi V Pathak (2003) Indian Financial System, Pierson Education, New Delhi.
14. Preethi Singh (2009) Dynamics of Indian Financial System, Markets, Institutions and services, Annes books Pvt. Ltd, New Delhi
15. Faboozi, J Frank, Modiglani Franco (2008): Capital markets – Institution &Instruments, 4th edition, Pierson Education, New Delhi.
16. Avadhani V A (1993) Investments & Securities Markets in India, Himalaya Publishing House, Mumbai
17. Machiraju M R, Indian financial system, Vikas Publishing House, New Delhi
18. Rajesh S Kothari, Financial Services in India, Concepts & Applications, Sage Publications.

THIRD SEMESTER
GDMT3B03T: MULTIVARIABLE CALCULUS

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

Aims, Objectives and Outcomes

The intention of the course is to extend the immensely useful ideas and notions such as limit, continuity, derivative and integral seen in the context of function of single variable to function of several variables. The corresponding results will be the higher dimensional analogues of what we learned in the case of single variable functions. The results we develop in the course of calculus of multivariable are extremely useful in several areas of science and technology as many functions that arise in real life situations are functions of multivariable.

The successful completion of the course will enable the student to

COs	COURSE OUTCOMES
CO1	Understand the use of partial derivatives in getting information of tangent plane and normal line
CO2	Calculate the maximum and minimum values of a multivariable function using second derivative test and Lagrange multiplier method
CO3	Find a few real life applications of Lagrange multiplier method in optimization problems.
CO4	Extend the notion of integral of a function of single variable to integral of functions of two and three variables.
CO5	Address the practical problem of evaluation of double and triple integral using Fubini's theorem and change of variable formula.
CO6	Realize the advantage of choosing other coordinate systems such as polar, spherical, cylindrical etc. in the evaluation of double and triple integrals.
CO7	See a few applications of double and triple integral in the problem of finding out surface area, mass of lamina, volume, centre of mass and so on.
CO8	Understand the notion of a vector field, the idea of curl and divergence of a vector field, their evaluation and interpretation.
CO9	Understand the idea of line integral and surface integral and their evaluations

Text	Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010) ISBN 0-534-46579-X)*

Module-I **(18hrs)**

13.1 : Functions of two or more variables- Functions of Two Variables, Graphs of Functions of Two Variables, Level Curves, Functions of Three Variables and Level Surfaces

13.2 : Limits and continuity-An Intuitive Definition of a Limit, *existence and non existence of limit,* Continuity of a Function of Two Variables, Continuity on a Set, *continuity of polynomial and rational functions, continuity of composite functions,* Functions of Three or More Variables, The Definition of a Limit

13.3 : Partial Derivatives- Partial Derivatives of Functions of Two Variables, *geometric interpretation,* Computing Partial Derivatives, Implicit Differentiation, Partial Derivatives of Functions of More Than Two Variables, Higher-Order Derivatives, *Clairaut theorem, harmonic functions*

13.4 : Differentials- Increments, The Total Differential, *interpretation,* Error in Approximating Δz by *[only statement of theorem1 required; proof omitted]* Differentiability of a Function of Two Variables, *criteria,* Differentiability and Continuity, Functions of Three or More Variables

13.5 : The Chain rule- The Chain Rule for Functions Involving One Independent Variable, The Chain Rule for Functions Involving Two Independent Variables, The General Chain Rule, Implicit Differentiation

Module-II **(16 hrs)**

13.6 : Directional Derivatives and Gradient vectors - The Directional Derivative, The Gradient of a Function of Two Variables, Properties of the Gradient, Functions of Three Variables 13.7: Tangent Planes and Normal Lines- Geometric Interpretation of the Gradient, Tangent Planes and Normal Lines, Using the Tangent Plane of f to approximate the Surface z=f(x, y) 13.8: Extrema of Functions of two variables - Relative and Absolute Extrema, Critical Points—Candidates for Relative Extrema, The Second Derivative Test for Relative Extrema, Finding the Absolute Extremum Values of a Continuous Function on a Closed Set

13.9: Lagrange Multipliers- Constrained Maxima and Minima, The Method of Lagrange Multipliers, *Lagrange theorem,* Optimizing a Function Subject to Two Constraints

Module-III **(30 hrs)**

14.1 : Double integrals- An Introductory Example, Volume of a Solid between a Surface and a Rectangle, The Double Integral over a Rectangular Region, Double Integrals over General Regions, Properties of Double Integrals

14.2 : Iterated Integrals-Iterated Integrals over Rectangular Regions, Fubini's Theorem for Rectangular Regions, Iterated Integrals over Nonrectangular Regions, - *simple and – simple regions, advantage of changing the order of integration*

14.3 : Double integrals in polar coordinates- Polar Rectangles, Double Integrals over Polar Rectangles, Double Integrals over General Regions, r-simple region, method of evaluation 14.5: Surface Area- Area of a Surface $z=(x,y)$, Area of Surfaces with Equations $y=g(x,z)$ and $x=h(y,z)$

14.6 : Triple integrals- Triple Integrals Over a Rectangular Box, *definition, method of evaluation as iterated integrals,* Triple Integrals Over General Bounded Regions in Space, Evaluating Triple Integrals Over General Regions, *evaluation technique*

14.7 : Triple Integrals in cylindrical and spherical coordinates- *evaluation of integrals in* Cylindrical Coordinates, Spherical Coordinates

14.8 : Change of variables in multiple integrals- Transformations, Change of Variables in Double Integrals *[only the method is required; derivation omitted]*, illustrations, Change of Variables in Triple Integrals

Module-IV **(16 hrs)**

15.1: Vector Fields- *V.F. in two and three dimensional space,* Conservative Vector Fields 15.2: Divergence and Curl- *Divergence- idea and definition,* Curl- *idea and definition*

15.3 : Line Integrals- *Line integral w.r.t. arc length-motivation, basic idea and definition,* Line Integrals with Respect to Coordinate Variables, *orientation of curve* Line Integrals in Space, Line Integrals of Vector Fields

15.4 : Independence of Path and Conservative Vector Fields-*path independence through example, definition, fundamental theorem for line integral,* Line Integrals Along Closed Paths,*work done by conservative vector field,* Independence of Path and Conservative Vector Fields, Determining Whether a Vector Field Is Conservative, *test for conservative vector field* Finding a Potential Function, Conservation of Energy

References:

1	JoelHass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson(2018) ISBN 0134438981*
2	Robert A Adams & Christopher Essex : Calculus: *A complete Course (8/e) Pearson Education Canada (2013) ISBN:* 032187742X
3	Jon Rogawski: Multivariable Calculus *Early Transcendentals* (2/e) W. H. Freeman and Company(2012) *ISBN: 1-4292-3187-4*
4	Anton, Bivens & Davis : Calculus *Early Transcendentals* (10/e) John Wiley & Sons, Inc.(2012) ISBN: 978-0-470-64769-1
5	James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978-1-285-74062-1*
6	Jerrold E. Marsden & Anthony Tromba :Vector Calculus (6/e) *W. H. Freeman and Company ,New York(2012) ISBN: 978-1-4292-1508-4*
7	Arnold Ostebee & Paul Zorn: Multivariable Calculus (2/e) *W. H. Freeman Custom Publishing, N.Y.(2008)ISBN: 978-1-4292-3033-9*

General Course
FOURTH SEMESTER
GDEC4A02T: INDIAN ECONOMY

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	Provides a critical understanding on change in sectorial composition of GDP, change in agricultural and industrial sectors
CO2	Students will get an understanding on the issues and policy developments in India
CO3	This course enables students to get a deep understanding of the economic policy decisions of government of India, reasons and logics behind such decisions, it's probable impacts

Module I : Nature of Indian economy. (10 Hrs)
Characteristics of Indian economy. Economic planning and development experience in the post-independence period. Population, unemployment and poverty. Sectoral distribution of employment and output.

Module II. Indian Agriculture (20 Hrs)
Nature and performance of Indian agriculture. Investment in agriculture and new agricultural strategy. Challenges of agriculture in the globalised world.

Module III. Indian Industries (20 Hrs)
Performance of industrial sector during the post-independence period. Industrial policies and liberalization trends. Current policies toward industrialization in India

Module IV. Indian public finance (10 Hrs)
Centre state financial relations and fiscal federalism. The role of financial commission. Sharing of resources and imbalances

Module V. Currency and Finance (10 Hrs)
Money market and capital market. Commercial Banks, Central Bank; functions – Credit Control, Banking sector reforms. Emerging trends in the Indian financial sector.

Module VI. External sector (10 Hrs)
Exports, imports and balance of payment position of India, Multinational companies and foreign direct investment. Recent policy initiatives toward foreign capital and investment

References:

1. Kaushik Basu : The Concise Oxford Companion to Economics in India (2010),Oxford
2. Isher Judge Ahluwalia and I M D Little: India's Economic Reforms and development (2014), OUP
3. Uma Kapila: Indian Economy since independence (2020)
4. Jagadish Bhagwati and Arvind Panagariya: Reforms and economic transformation in India(2013) OUP
5. Bimal Jalan: Indian Economy, Penguin books

FOURTH SEMESTER
GDEC4B05T: MICROECONOMICS - II

Lecture Hours: 96 (6 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	Evaluate General equilibrium and different theories of welfare economics and their relevance in government policies.
CO2	To enable students to analyze different market structures and their applicability in the contemporary world
CO3	To understand the basic theories of factor pricing and distribution.
CO4	To explore the situation of market failures

Module I: General Equilibrium, Efficiency and Welfare (30 Hrs)
Perfect competition. Profit maximization of a competitive firm. Partial equilibrium competitivemodel. Firm supply. Industry supply. General equilibrium and welfare. Overall efficiency and welfare economics

Module II: market structure and game theory (20 Hrs)
Pricing with market power. monopoly.equilibrium. Price discrimination. Monopolistic competition. Oligopoly. Models of oligopoly- Cournot, Bertrand, Stackelberg, Sweezy. Collusive models. Game theory- Nash equilibrium, Prisonner's dilemma, Domonant strategy, mixed strategies.

Module III: (16 Hrs)
Pricing in input markets, labour supply,demand and equilibrium, monopsony in the labour market, labour unions

Module IV: Market failure (30 Hrs)
Externalities,Externalities and allocative efficiency, solution to negative externality problem. Public goods , attributes of public goods and resource allocation, Lindahl pricing of public goods, voting and allocation of public goods. Asymmetric information. adverse selection, moral hazard, signaling, auctions

References:

1.Hal R Varian (2014) - *Intermediate Microeconomics with calculus*, 1st edition, W WNorton and Company
2.Christopher Snyder and Walter Nicholson (2017) - *Microeconomic Theory-BasicPrinciples and Extensions*, Cengage Learning
3.Dominick Salvatore (2003): Microeconomics: Theory and Applications- 4thEdition,Oxford University Press.
4. Robert S Pindyck and Daniel L Rubinfeld (2009): Microeconomics- 8th Edition,Pearson India.
5.Hal R Varian and Theodore C Bergstrom(2014)- Workouts in intermediate microeconomics (This book may be used for solving problems)

FOURTH SEMESTER
GDMT4A02T: THEORY OF EQUATIONS AND COMPLEX NUMBERS

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	At the end of the course students get used to different ways of solving equations and they begin to prove many properties in their own way regarding numbers
CO2	At the end of the course students get the idea of Complex numbers and their properties, Complex Functions and Special Power functions.

Text (1)	Theory of Equations : J V Uspensky McGraw Hill Book Company, Inc. (1948), ISBN:07-066735-7
Text (2)	Complex Analysis A First Course with Applications (3/e): Dennis Zill & Patric Shanahan Jones and Bartlett Learning (2015), ISBN :1-4496-9461-6

Module – I **Text (1)** **(20 hrs)**

Chapter II (Text 1)

II.1 Integral rational functions or polynomials.
II.2 Multiplication of polynomials.
II.3 Division of polynomials, quotient and remainder, method of detached coefficients
II.4 The remainder theorem
II.5 Synthetic Division
II.6 Horner's process
II.7 Taylor formula, expansion of a polynomial in powers of $x - c$
II.8 Highest common divisor of two polynomials

Chapter III (Text 1)

III.1 Algebraic equations, roots, maximum number of roots
III.2 Identity theorem
III.3 The Fundamental theorem of Algebra (statement only), factorisation to linear factors, multiplicity of roots
III.4 Imaginary roots of equations with real coefficients
III.5 Relations between roots and coefficients
III.6 Discovery of multiple roots

Module – II **Text (1)** **(20 hrs)**

Chapter IV (Text 1)

IV.1 Limits of roots
IV.2 Method to find upper limit of positive roots
IV.3 Limit for moduli of roots [only the method to find out upper limit from the auxiliary equation is required; derivation omitted]
IV.4 Integral roots
IV.5 Rational roots

Chapter V (Text 1)

V.1 What is the solution of an equation?
V.2 Cardan's formulas
V.3 Discussion of solution
V.4 Irreducible case
V.5 Trigonometric solution
V.6 Solutions of biquadratic equations, Ferrari method [example2 omitted]

Module – III Text (1) (20 hrs)

Chapter VI (Text 1)

VI.1 Object of the Chapter
VI.2 The sign of a polynomial for small and large values of variables- locating roots of polyno- mial between two numbers having values of opposite sign-geometric illustration only-[rigorous reasoning in the starred section omitted]
VI.4 Corollaries- roots of odd and even degree polynomial, number of roots in an interval counted according to their multiplicity
VI.5 Examples
VI.6 An important identity and lemma [derivation not needed]
VI.7 Rolle' s Theorem [proof omitted], use in separating roots
VI.10 Descarte's rule of signs-only statement and illustrations are required

Chapter XI (Text 1)

XI.1 : Symmetric Functions –definition, sigma functions, elementary symmetric functions
XI.4 : Practical Methods-representation of symmetric functions through elementary symmetric functions

Module – IV Text (2) (20 hrs)

1.1 : Complex numbers and their properties - definition, arithmetic operations, conjugate, inverses, reciprocal
1.2 : Complex Plane - vector representation, modulus, properties, triangle inequality
1.3 : Polar form of complex numbers - polar representation, principal argument, multiplication and division, argument of product and quotient, integer powers, de Moivre's formula.
1.4 : Powers and roots - roots, principal nth root
1.5 : Sets of points in the complex plane - circles, disks and neighbourhoods, open sets, annulus, domains, regions, bounded sets
2.1 : Complex Functions - definition, real and imaginary parts of complex function, complex exponential function, exponential form of a complex number, Polar Coordinates
2.2 : Complex Functions as mappings - complex mapping, illustrations, Parametric curves in complex planes, common parametric curves, image of parametric curves under complex mapping [The subsection 'Use of Computers' omitted]
2.3 : Linear Mappings- Translations, Rotations, Magnifications, general linear mapping, image of geometric shapes under linear map.
2.4 : Special Power functions- The power function z^n, The power function $z^{\frac{1}{n}}$, principal square root function, Inverse Functions, multiple valued functions

References:

1. Dickson L.E : Elementary Theory of Equations John Wiley and Sons,Inc. NY (1914)
2. Turnbull H.W : Theory of Equations (4/e) Oliver and Boyd Ltd. Edinburg (1947)
3. Todhunter I : An Elementary Treatise on the Theory of Equations(3/e) Macmillan and Co. London(1875)
4. William Snow Burnside and Arthur William Panton : The Theory of Equations with An Introduction to Binary Algebraic Forms Dublin University Press Series(1881
5. James Ward Brown, Ruel Vance Churchill: Complex variables and applications (8/e), McGraw-Hill Higher Education, (2009) ISBN: 0073051942
6. Alan Jeffrey : Complex Analysis and Applications (2/e), Chapman and Hall/CRC Taylor Francis Group (2006), ISBN:978-1-58488-553-5
7. Saminathan Ponnusamy, Herb Silverman: Complex Variables with Applications Birkhauser Boston(2006) ISBN:0-8176-4457-4
8. John H. Mathews & Russell W. Howell : Complex Analysis for Mathematics and Engineering (6/e)
9. H A Priestly : Introduction to Complex Analysis (2/e), Oxford University Press, (2003), ISBN: 0-19-852562-1
10. Jerrold E Marsden, Michael J Hoffman: Basic Complex Analysis (3/e) W.H Freeman, N.Y. (1999) ISBN:0-7167-2877-X

FOURTH SEMESTER
GDMT4B04T: ABSTRACT ALGEBRA

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

Aims, Objectives and Outcomes

Credit goes to the brilliant mathematician Evariste Galois for proving this fact and he developed an entire theory that connected the solvability by radicals of a polynomial equation with the *permutation group* of its roots. The theory now known as *Galois theory* solves the famous problem of *insolvability of quintic.* A study on *symmetric functions* now becomes inevitable. One can now observe the connection emerging between classical algebra and modern algebra. The four modules are therefore devoted to the discussion on basic ideas and results of abstract algebra. Students understand the abstract notion of a group, learn several examples, are taught to check whether an *algebraic system* forms a group or not and are introduced to some fundamental results of group theory. The idea of structural similarity, the notion of cyclic group, permutation group, various examples and very fundamental results in the areas are also explored.

COs	COURSE OUTCOMES
CO1	Students understand the abstract notion of a group, learn several examples, are taught to check whether an algebraic system forms a group or not and are introduced to some fundamental results of group theory
CO2	Students understand the idea of structural similarity, the notion of cyclic group, permutation group, various examples and very fundamental results in the areas

Text	Algebra(3/e)*:*John A Beachy and William D Blair *WavelandPress, Inc.(2006) ISBN: 1-57766-443-4*

Module-I **(15 hrs)**

1.4: Integers modulo n- congruence class modulo n, addition and multiplication, divisor of zero, multiplicative inverse

2.2 : Equivalence relations- basic idea, definition, equivalence class, factor set, partition and equivalence relation, examples and illustrations

2.3 : Permutations- definition, cycles, product of cycles, permutation as product of disjoint cycles, order of cycles, transposition, even and odd transpositions

Module-II **(25 hrs)**

3.1 : Definition of Group- binary operation, uniqueness of identity and inverse, definition and examples of groups, properties, Abelian group, finite and infinite groups, general linear groups

3.2 : Subgroups- the notion of subgroup, examples, conditions for a subgroup, cyclic subgroups, order of an element, Lagrange theorem, Euler's theorem

3.3 : constructing examples- groups with order upto 6, multiplication table, product of subgroups, direct products, Klein four group as direct product, subgroup generated by a subset

3.4 : Isomorphism – definition, consequences, structural properties, method of showing that groups are not isomorphic, isomorphic and non isomorphic groups.

Module-III **(25 hrs)**

3.5 : Cyclic groups- subgroups of cyclic groups, characterisation, generators of a finite cyclic group, structure theorem for finite cyclic group, exponent of a group, characterisation of cyclic groups among finite abelian groups.

3.6 : Permutation groups- definition, Cayley's theorem, rigid motions of n-gons, dihedral group, alternating group

3.7 : Homomorphism - basic idea, examples, definition, properties, kernel, normal subgroups, subgroups related via homomorphism

Module-IV **(15 hrs)**

3.8 : Cosets- left and right cosets, normal subgroups and factor groups, fundamental homomorphism theorem, simple groups, examples and illustrations of concepts

5.1: Commutative Rings; Integral Domains- definition, examples, subring, criteria to be a subring, divisor of zero, integral domain, finite integral domain.

7.1: (Structure of Groups) Isomorphism theorems; Automorphism- first isomorphism theorem,second isomorphism theorem, inner automorphism (Statements only)

Reference:

1 Joseph A. Gallian : Contemporary Abstract Algebra(9/e) *Cengage Learning, Boston(2017) ISBN: 978-1-305-65796-0*

2 John B Fraleigh : A First Course in Abstract Algebra(7/e) *Pearson Education LPE(2003) ISBN 978-81-7758-900-9*

3 David Steven Dummit, Richard M. Foote: Abstract Algebra(3/e) *Wiley, (2004) ISBN: 8126532289*

4 Linda Gilbert and Jimmie Gilbert: Elements of Modern Algebra (8/e) *Cengage Learning, Stamford(2015) ISBN: 1-285-46323-4*

5 John R. Durbin : Modern Algebra: An Introduction(6/e) *Wiley(2015) ISBN: 1118117611*

6 Jeffrey Bergen: A Concrete Approach to Abstract Algebra- From the integers to Insolvability of Quintic *Academic Pres [Elsever](2010)ISBN: 978-0-12-374941-3*

FOURTH SEMESTER
GDMT4B05T: DISTRIBUTION THEORY

Lecture Hours: 64(4 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	To derive various descriptive statistics; verify the existence of reproductive property of distributions using generating functions-their limitations and advantages
CO2	To understand various theoretical probability distributions and their applications

Module I: **(16 Hrs)**
Concept of a random Variable, Distribution function, Discrete and continuous randomvariable, PMF and PDF, Bivariate random variable, Discrete and continuous joint PDF and massfunction, Marginal and conditional distributions, Mathematical expectation, Moment skewness and kurtosis using moments, Moment generating function covariance and correlation coefficient

Module II: **(16 Hrs)**
Discrete distributions, PGF of a discrete random variable uniform binomial, Poisson geometric, Negative binomial, Hypergeometric and multinomial distribution, Their properties and interrelationships

Module III: **(16 Hrs)**
Continuous distributions, Uniform and exponential distributions, Distribution of functions of random variables for univariate and bivariate random variables, Gamma and beta distribution, Weibul, Pareto, Cauchy normal and lognormal distributions, Bivariate normal distribution.

Module IV: **(16 Hrs)**
Chebyshev's inequality, sequence of random variables parameter and statistics, Sample mean and variance convergence in probability and weak law of large numbers, Central limit theorem (iid case only), Sampling distributions standard error of a statistics, Sampling distributions – χ^2, t and F distributions and their relationships.

References:

1. Rohatgi V.K and Sleh A.K (2009) Introduction to probability and statistics Wiley India
2. Saeed Ghahramani (2012) Fundamentals of probability and stochastic process Pearson
3. Hogg and Tanis (2002) Probability and statistical inference Pearson Education Asia
4. Michael J Evans and Jefrey S Rosenthal Probability and statistic : The science of uncertainty University of Toronto (Book pdf)

FIFTH SEMESTER
GDEC5B06T : MACROECONOMICS II

Lecture Hours: 64 (4 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	After completing this course a student should be able to explain the concept of consumption and investment and factors affecting it in a country
CO2	Also, a student should be able to explain the components of money supply and demand in an economy.
CO3	A clear understanding of the monetary and fiscal poly enables students to review economic activities and its impact on the economy

Module I: Microeconomic Foundations (20 Hrs)
a). Consumption. Keynesian consumption function. Fisher's theory of intertemporal choice. Life–cycle and Permanent income hypotheses. Rational expectations and Random Walk hypothesis. b). Investment. Business fixed investment, determinants. Residential investment. Inventory investment. Keynesian theory of investment, MEC and MEI, Accelerator theory of investment, Tobin's q ratio.

Module II: Money Supply and Money Demand (20 Hrs)
a). Money supply. Money supply process. Money multiplier.
b). Money demand. portfolio theories of money demand, Transaction theories of money demand, The Baumol – Tobin model of cash management. Friedman's restatement of quanity theory of money

Module III: Fiscal and Monetary Policy (14 Hrs)
Active or passive, Monetary policy objective and targets. Rules versus discretion, Time inconsistency. Government budget constraint. Government debt and Ricardian equivalence.

Module IV: Schools of Macroeconomic Thought (10 Hrs)
Major themes of Classical, Keynesian, Monetarist, newclassical, real business cycle and New Keynesian schools

References:

1. N Dornbusch, S Fischer and R Startz (2018) - Macroeconomics, 12th edition, McGraw publishers
2. N. Gregory Mankiw 2018) - Macroeconomics,10th edition, Worth Publishers,
3. Olivier Blanchard (2017) - Macroeconomics, 6th edition, Pearson Education,
4. Richard T. Froyen (2013)- Macroeconomics: Theories and Policies, 10th edition Pearson Education
5. Andrew B. Abel and Ben S. Bernanke (2011)- Macroeconomics, 7th edition, Pearson education
6. Brian Snowdon and Howard Vane (2005) - Modern Macroeconomics, its origin development and current state, 1st edition

FIFTH SEMESTER
GDEC5B07T: ECONOMETRICS I

Lecture Hours: 64 (4 Hrs/Week) **Credits: 3**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	The students will get a foundation for econometric analysis and develop skills for empirical research.
CO2	The students will get basic research aptitude by solving various real life economic problems.
CO3	The topic equips students to get careers in the fields of social science research.

Module I: Nature and Scope of Econometrics (05 Hrs)

Module II: Simple Linear Regression Model (18 Hrs)
The concept of PRF -Significance of stochastic error term-The SRFMethod of ordinary least squares-Assumptions -Properties of estimators- Gauss Markov theorem- Coefficient of determination, r^2 -Normality assumption-Hypothesis testing- t and F tests. P value. -Prediction-Method of maximum likelihood-Maximum likelihood estimation of two variable model.
Regression through the origin-Functional forms of regression models, log-log, log-lin, lin-log and reciprocal models.

Module III: Multiple Regression Analysis (17 Hrs)
The three variable model-OLS estimation of partial regression coefficients-Multiple coefficient of determination R^2 and adjusted R^2- Testing the overall significance of the regression model- F test-Restricted least squares. General k variable regression model- Matrix approach to estimation and derivation of the properties of OLS estimators. Dummy variables

Module IV: Econometric Problems (15 Hrs)
Multicollinearity- Nature, consequences, detection and remedial measures-Autocorrelation-Nature, consequences, detection, and remedial measures- Heteroskedasticity-Nature, consequences, detection and remedial measures.

Module V: Model Specification and Diagnostic Testing (9 Hrs)
Types of specification errors- Detection and consequences. -Errors of measurement-Consequences, remedies.

References:

1: Damodar N Gujarati and Dawn C Porter(2009)- Basic Econometrics, Fifth edition,McGrawHill International Edition .
2: Jeffrey M Wooldridge (2018) – Introductory Econometrics, a Modern Approach, 7th edition,Thomson South Western.
4. Dimitrios Asteriou and Robert Hall (2015) – Applied econometrics, 3nd edition, Oxforduniversity press

FIFTH SEMESTER
GDMT5B06T: LINEAR ALGEBRA

Lecture Hours: 64 (4 Hrs/Week) **Credits: 3**
Marks: 75 (Internal: 15, External: 60) **Examination: 2 Hours**

Aims, Objectives and Outcomes

An introductory treatment of linear algebra with an aim to present the fundamentals in the clearest possible way is intended here. Linear algebra is the study of linear systems of equations, vector spaces, and linear transformations. Virtually every area of mathematics relies on or extends the tools of linear algebra. Solving systems of linear equations is a basic tool of many mathematical procedures used for solving problems in science and engineering. A number of methods for solving a system of linear equations are discussed. In this process, the student will become competent to perform matrix algebra. Another advantage is that the student will come to understand the modern view of a matrix as a linear transformation. The discussion necessitates the introduction of central topic of linear algebra namely the concept of a *vector space*. Several examples and general properties of vector spaces are studied. The idea of a subspace, spanning vectors, basis and dimension are discussed and fundamental results in these areas are explored.

COs	**COURSE OUTCOMES**
CO1	Linear maps are introduced. The key result here is that for a linear map T, the dimension of the null space of T plus the dimension of the range of T equals the dimension of the domain of T.
CO2	The part of the theory of polynomials that will be needed to understand linear operators is presented.
CO3	The idea of studying a linear operator by restricting it to small subspaces to eigenvectors. The highlight is a simple proof that on complex vector spaces, eigenvalues always exist. This result is then used to show that each linear operator on a complex vector space has an upper-triangular matrix with respect to some basis. Similar techniques are used to show that every linear operator on a real vector space has an invariant subspace of dimension 1 or 2. This result is used to prove that every linear operator on an odd-dimensional real vector space has an eigenvalue. All this is done without defining determinants or characteristic polynomials

Text(1)	Frank Ayres JR: Matrices, Schaum's Outline Series, TMH Edition.
Text(2)	Linear Algebra Done Right : Sheldon Axler, Second Edition, Springer

Module-I **(21 hrs)**

(Relevant sections from Text 1).
Rank of a Matrix, Non-Singular and Singular matrices, Elementary Transformations, Inverse of an elementary Transformations, Row Canonical form, Normal form.
Systems of Linear equations: Homogeneous and Non Homogenoeus Equations, Characteristic equation of a matrix; Characteristic roots and characteristic vectors.
Statement of Cayley Hamilton Theorem and simple applications.

Module-II **(22 hrs)**

Chapter1 (Text2)
Vector Spaces , Complex Numbers , Definition of Vector Space, Properties of Vector Spaces, Subspaces , Sums and Direct Sums
Chapter 2 (Text2)
Finite-Dimensional Vector Spaces, Span and Linear Independence, Bases, Dimension

Module-III **(21 hrs)**

Chapter 3 (Text2)
Linear Maps, Definitions and Examples, Null Spaces and Ranges, The Matrix of a Linear Map, Invertibility (Proof of Proposition 3.17 omitted)

References:

1. Jim DeFranza, Daniel Gagliardi: Introduction to Linear Algebra with Applications *Waveland Press, Inc(2015)ISBN: 1-4786-2777-8*
2. Otto Bretscher: Linear Algebra with Applications(5/e) Pearson Education, Inc (2013) ISBN: 0-321-79697-7
3. Ron Larson, Edwards, David C Falvo : Elementary Linear Algebra(6/e) *Houghton Mifflin Harcourt Publishing Company(2009) ISBN: 0-618-78376-8*
4. David C. Lay, Steven R. Lay, Judi J. McDonald: Linear Algebra and its Application (5/e) *Pearson Education, Inc(2016) ISBN: 0-321-98238-X*
5. Martin Anthony, Michele Harvey: Linear Algebra: Concepts and Methods *Cambridge University Press(2012) ISBN: 978-0-521-27948-2*
6. Jeffrey Holt: Linear Algebra with Applications *W. H. Freeman and Company (2013) ISBN: 0-7167-8667-2*

FIFTH SEMESTER
GDMT5B07T: REAL ANALYSIS

Lecture Hours: 64 (4 Hrs/Week) **Credits: 3**
Marks: 75 (Internal: 15, External: 60) **Examination: 2 Hours**

Aims, Objectives and Outcomes

In this course, basic ideas and methods of real and complex analysis are taught. Real analysis is a theoretical version of single variable calculus. So many familiar concepts of calculus are reintroduced but at a much deeper and more rigorous level than in a calculus course. At the same time there are concepts and results that are new and not studied in the calculus course but very much needed in more advanced courses. The aim is to provide students with a level of mathematical sophistication that will prepare them for further work in mathematical analysis and other fields of knowledge, and also to develop their ability to analyze and prove statements of mathematics using logical arguments. The course will enable the students

COs	COURSE OUTCOMES
CO1	To learn and deduce rigorously many properties of real number system by assuming a few fundamental facts about it as axioms. In particular they will learn to prove Archimedean property, density theorem, existence of a positive square root for positive numbers and so on and the learning will help them to appreciate the beauty of logical arguments and embolden them to apply it in similar and unknown problems

Text 1	Introduction to Real Analysis (4/e): Robert G Bartle, Donald R Sherbert *John Wiley & Sons (2011) ISBN 978-0-471-43331-6*

Module-I **(18 hrs)**

(Text 1)

Chapter 1: Preliminaries

1.3: Finite and Infinite Sets

Chapter 2: The Real Numbers

2.1: The Algebraic and Order Properties of $\mathbb{R}$

2.2: Absolute Value and the Real Line

Module-II **(24 hrs)**

(Text 1)

2.3: The Completeness Property of $\mathbb{R}$

2.4: Applications of the Supremum Property

2.5: Intervals (Binary, decimal and periodic representations omitted)

Chapter 3: Sequences and Series

3.1: Sequences and Their Limits

3.2: Limit Theorems

3.3: Monotone Sequences

Module-III **(22 hrs)**

(Text 1)

3.4 : Subsequences and the Bolzano-Weierstrass Theorem

3.5: The Cauchy Criterion

3.6: Properly divergent sequences

3.7: Introduction to Infinite Series

5.4: Uniform Continuity- [Definitions Only]

References:

1. Charles G. Denlinger: Elements of Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2011) ISBN:0-7637-7947-4 [Indian edition:ISBN- 9380853157]*
2. David Alexander Brannan: A First Course in Mathematical Analysis *Cambridge University Press,US(2006) ISBN: 9780521684248*
3. John M. Howie: Real Analysis *Springer Science & Business Media(2012)[Springer Undergraduate Mathematics Series] ISBN: 1447103416*
4. James S. Howland: Basic Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2010) ISBN:0-7637-7318-2*
5. Terrace Tao: Analysis 1(3/e) *TRIM 37 Hindustan book agency(2016)*
6. Richard R Goldberg: Methods of Real Analysis *Oxford and IBH Publishing Co.Pvt.Ltd. NewDelhi(1970)*

FIFTH SEMESTER
GDMT5B08T: STATISTICAL INFERENCE

Lecture Hours: 64 (4 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	Understand the theory essential for estimation of unknown parameters
CO2	Understand various sampling distributions and the related concepts , criteria of good estimators and interval estimation

Module I: **(16 Hrs)**

Population and sample, Census and Sample surveys, Simple random sample with andwithout replacement, Systematic sampling, Stratified sampling, Cluster sampling [concepts only], Sampling from an infinite population, Parameter and statistics, Concept of sufficient of statistics and factorization theorem.

Module II: **(16 Hrs)**

Estimation – Properties of an estimator : unbiasedness, Consistency, efficiency and completeness, Minimum variance unbiased estimators, Rao-Cramer inequality and minimum variance bound estimator, Maximum likelihood and moment estimators, Interval estimation, Confidence interval for mean and variance of a normal population, Confidence interval for binomial proportion.

Module III: **(16 Hrs)**

Testing of hypothesis – Null and alternative hypothesis, Simple and composite hypothesis, Critical region and level of significance and P value of test, Most powerful test and Neymen-Pearson lemma, Uniformly most powerful tests, Likelihood ratio tests, Large sample tests, Test for single mean, Equality of two means, Test of proportions, Small sample tests

Module IV: **(16 Hrs)**

Tests based on χ^2 and F distributions, χ^2 test for equality of variance of a single population, χ^2 test for goodness of fit and independent of attributes, F-test for equality of twovariances, ANOVA one way and two way classification, Non parametric methods, Kolmogorov Smirnov test, Sign test, Wilcoxen signed rank test, Mann Whitney U-test, Run test, Kruskal Wallis test

References:

1. Hogg and Tanis ((2002) Probability and statistical inferences Pearson education Asia
2. Rohatgi V.K and Saleh A.K (2009) Introduction to probability and statistics Wiley India
3. George Casella and Roger Berger (2012) Statistical Inference Wadsworth and Brooks,California
4. S C Gupta and V k Kapoor “Fundamentals of mathematical statistics” sultan Chand

SIXTH SEMESTER
GDEC6B08T: ECONOMETRICS II

Lecture Hours: 80 (5 Hrs/Week) **Credits: 3**
Marks: 75 (Internal: 15, External: 60) **Examination: 2 Hours**

Module I: Qualitative Response Regression Models (10 Hrs)
The linear probability model (LPM)- The logit model- The probit model- The tobit model.

Module II: Dynamic Econometric Models (12 Hrs)
Autoregressive and distributed-lag models-Role of lag in economics-The Koyck approach-The adaptive expectations model- Stock adjustment model-Estimation of autoregressive models- The method of instrumental variable (IV)- Durbin h test- Almon approach to distributed lag models.

Module III: Panel Data Regression Models (08 Hrs)
Fixed effects model-The random effects model.

Module IV: Simultaneous Equation Methods (16 Hrs)
Simultaneous equation bias-The identification problem-Rules of identification- Rank and order condition- Simultaneous equation methods-Limited information versus full information methods-Recursive models and ordinary least squares-The method of indirect least squares (ILS)-The method of two stage least squares (2SLS)-Instrumental variable estimation-Properties of various estimators.

Module V: Instrumental Variables Regression (12 Hrs)
Instrumental variables estimator with a single regressor and a single instrument- The general IV model-Checking instrument validity, instrument relevance and instrument exogeneity.

Module VI: Time Series Econometrics (14 Hrs)
Stochastic processes, stationary versus nonstationary stochastic processes-Unit roots- Trend stationary versus difference stationary stochastic processes- Spurious regression-Testing for unit roots- Dickey Fuller and Augmented Dickey Fuller tests-Cointegration and error correction models

Module VII: (08 Hrs)
Econometric applications with EVIEWS or STATA

References:

1. Damodar N Gujarati and Dawn C Porter(2009)- Basic Econometrics, Fifth edition, McGraw Hill International Edition.
2. Jeffrey M Wooldridge (2018) – Introductory Econometrics, a Modern Approach, 7th edition, Thomson South Western.
3. Dimitrios Asteriou and Robert Hall (2015) – Applied econometrics, 3nd edition, Oxford university press

SIXTH SEMESTER
GDEC6B09T: INTERNATIONAL ECONOMICS

Lecture Hours: 64 (4 Hrs/Week) **Credits: 3**
Marks: 75 (Internal: 15, External: 60) **Examination: 2 Hours**

Introduction

International economics deals with the economic relations – among nations - both trade and financial. A good understanding of international economics is necessary of student of Economics and those who wish to work in these areas or governmental organizations.

Objectives

The basic aim of this introductory course on international economics is to present before the students the questions, and answers, related to international economic relations.

COs	COURSE OUTCOMES
CO1	The students are expected to acquire skill that will help them to take rational decisions in issues related international economics

Syllabus

Module 1: Introduction to theories on International trade (20 Hrs)
Internal Trade and International Trade- History of the development of trade theories - Classical Theory: Absolute and comparative cost Advantage theories, Hecksher Ohlin Theory, Stolper Samuelson effects- Leontief Paradox.

Module 2: Theory of Commercial Policy: (20 Hrs)
Free trade – Protection - Methods of Trade Restriction - Economics of Tariffs - Neo Protectionism - Economics of Quotas, Dumping, Cartel - Protection and Imperfect Competition - Economic Integration.

Module 3: Foreign Exchange: (14 Hrs)
Foreign exchange Market - exchange rate - Different Theories of exchange rate determination - Mint Parity, PPP, Monetary approach, Asset Market Model - Fixed and Flexible Exchange rate. - Devaluation, revaluation, depreciation and appreciation.

Module 4: Balance of Payments (10 Hrs)
Components - Balance of Trade and Balance of Payment - Equilibrium and disequilibrium in BOP – reasons and Measures to correct BOP disequilibrium - BOP in India.

Reference:

1. Salvatore, Dominick, 'International Economics', Weily India New Delhi.
2. C.P. Kindle Berger 'International Economics'
3. Bo Soderstein and Geoffrey Reed 'International Economics' Macmilon 27
4. Francis Cherumilam - 'International Economics'
5. Mannur, H.G. 'International Economics'
6. Errol D'Souza, 'Macro Economics', Pearson Education 2008 (For BOP in India)
7. RBI bulletin, Various issues.

SIXTH SEMESTER
GDEC6B10P: COMPUTER ORIENTED STATISTICAL METHODS

Lecture Hours: 64 (4 Hrs/Week) **Credits: 4**
Marks: 100[Internal: 20, External: 80(Record:20 & Practical Exam:60)]

COs	COURSE OUTCOMES
CO1	To develop scientific and experimental skills to correlate theoretical principles of statisticswith application based studies
CO2	To familiarise the students with basics of statistics softwares R and SPSS

Course Contents
The course has Theory Part (*Internal evaluation*) and Practical Part (*for internal and external evaluation*). A student has to maintain a practical record of the work.

Module I: **(13 Hrs)**
Introduction to the statistical software R, Data objects in R, Creating vectors, Creating matrices, Manipulating data, Accessing elementsof avector or matrix, Lists, Addition, Multiplication, Subtraction, Transpose,Inverseofmatrices. Readafile. Booleanoperators

Module II: **(18 Hrs)**
Descriptive statistics using R, Measures of central tendency, Measures of dispersion, R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Matplot, Plot options; Multiple plots in a single graphic window, Adjusting graphical parameters. Looping-For loop, repeat loop, while loop, if command, if else command

Module III: **(19 Hrs)**
Introduction to SPSS ,Preparing data file, Inputting transforming and sorting data,Descriptive statistics using SPSS, Measures of central tendency, Measures of dispersion, Frequency tables, Graphical representation of data, Pearson correlation and rank correlation, Simple linear regression, multiple linear regression, logistic regression

Module IV: **(14 Hrs)**
Statistical inference using SPSS, Checking normality of data, Independent samplet-test, Paired sample t-test, One-way ANOVA and two-way ANOVA, Cross tabs odds ratio and Chi-square test, Non parametric tests, Mann-Whitney U test, Wilcoxon signed rank test, Kruskal-Wallis test.

References:

1. Alain F. Zuur, Elena N. Ieno, and Erik Meesters (2009): ”A Beginner’s Guide to R” Springer, ISBN:978-0-387-93836-3.
2. MichaelJ.Crawley(2005):”Statistics: An Introductionusing R”,Wiley,ISBN0-470-02297-3
3. Phil Spector (2008): ”Data Manipulation with R”, Springer, New York, ISBN 978-0-387-74730-9.
4. Field A., “Discovering Statistics Using SPSS”, Fourth Edition, SAGE, 2013
5. Daniel j Denis (2018) , “SPSS Data analysis for univariate bivariate and multivariate statistics” Wiley, ISBN:9781119465775

Examination Pattern
GDEC6B10P: COMPUTER ORIENTED STATISTICAL METHODS
Marks: 100[Internal: 20, External: 80(Record:20 & Practical Exam:60)]

Pattern of External Practical Examination

Time 2 ½ Hours **Max. Marks: 60**

Section A (Each question carries 2.5 Marks)

I. Answer any 2 questions out of 3 from R programming
II. Answer any 2 questions out of 3 from SPSS

(4x2.5 = 10 Marks)

Section B (Each question carries 5 Marks)

III. Answer any 1 question out of 2 from R programming
IV. Answer any 1 question out of 2 from R programming
V. Answer any 1 question out of 2 from SPSS
VI. Answer any 1 question out of 2 from SPSS

(4 x 5 = 20 Marks)

Section C (Each question carries 15 Marks)

VII. Answer any 1 question out of 2 from R programming
VIII. Answer any 1 question out of 2 from SPSS

(2 x 15 = 30 Marks)

SIXTH SEMESTER
GDMT6B09T. NUMERICAL ANALYSIS

Lecture Hours: 80 (5 Hrs/Week) **Credits: 5**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

Aims, Objectives and Outcomes

The goal of numerical analysis is to provide techniques and algorithms to find *approximate numerical solution* to problems in several areas of mathematics where it is impossible or hard to find the actual/closed form solution by analytical methods and also to make an *error analysis* to ascertain the accuracy of the *approximate solution.* The subject addresses a variety of questions ranging from the approximation of functions and integrals to the approximate solution of algebraic, transcendental, differential and integral equations, with particular emphasis on the stability, accuracy, efficiency and reliability of numerical algorithms. The course enables the students to

COs	COURSE OUTCOMES
CO1	Understand several methods such as bisection method, fixed point iteration method, regulafalsi method etc. to find out the approximate numerical solutions of algebraic and transcendental equations with desired accuracy.
CO2	Understand the concept of interpolation and also learn some well known interpolation techniques.
CO3	Understand a few techniques for numerical differentiation and integration and also realize their merits and demerits.
CO4	Find out numerical approximations to solutions of initial value problems and also to understand the efficiency of various methods

Text	Numerical Analysis (10/e): *Richard L. Burden, J Douglas Faires, Annette M. Burden, Brooks Cole Cengage Learning(2016)* *ISBN:978-1-305-25366-7*

Module-I **(20 hrs)**

Solutions of Equations in One Variable

Note: Students should be familiar with concepts and definitions such as 'round off error', 'rate of convergence' etc. discussed in sections 1.2 and 1.3

Introduction

2.1: The Bisection Method

2.2: Fixed-Point Iteration

2.3: Newton's Method and Its Extensions- *Newton's Method (Newton-Raphson method), Convergence using Newton's Method, The Secant Method, The Method of False Position*

[derivation of formula omitted in each case]

[Algorithms are omitted]

Module-II **(20hrs)**

Interpolation and Polynomial Approximation

Introduction

3.1: Interpolation and the Lagrange Polynomial- *motivation,* Lagrange Interpolating Polynomials, *error bound*

3.3: Divided Differences- k^{th} *divided difference*, *Newton's divided difference formula,* Forward Differences, Newton Forward-Difference Formula, Backward Differences, Newton Backward–Difference Formula, Centered Differences, *Stirling's formula.*

[derivation of formula omitted in each case]

[Algorithms are omitted]

Module-III **(20hrs)**

Numerical Differentiation and Integration

Introduction

4.1: Numerical Differentiation- *approximation of first derivative by forward difference formula, backward difference formula, Three-Point Formulas, Three-Point Endpoint Formula, Three-Point Midpoint Formula [Five-Point Formulas, Five-Point Endpoint Formula, Five-Point Midpoint Formula omitted]* Second Derivative Midpoint Formula *to approximate second derivative,* Round-Off Error Instability

4.3: Elements of Numerical Integration-*numerical quadrature,* The Trapezoidal Rule, Simpson's Rule, Measuring Precision, Closed Newton-Cotes Formulas, Simpson's Three-Eighths rule, Open Newton-Cotes Formulas

[derivation of formula omitted in each case]

[Algorithms are omitted]

Module-IV **(20 hrs)**

Initial-Value Problems for Ordinary Differential Equations

Introduction

5.1 The Elementary Theory of Initial-Value Problems

5.2: Euler's Method- *derivation using Taylor formula,* Error bounds for Euler Method

5.3: Higher-Order Taylor Methods- *local truncation error, Taylor method of order n and order of local truncation error*

5.4: Runge-Kutta Methods- *only* Mid Point Method, Modified Euler's Method and Runge-Kutta Method of Order Four are required.

[derivation of formula omitted in each case]

[Algorithms are omitted]

References:

1 Kendall E. Atkinson, Weimin Han: Elementary Numerical Analysis(3/e) *John Wiley & Sons(2004) ISBN:0-471-43337-3[Indian Edition by Wiley India ISBN: 978-81-265-0802-0]*

2 James F. Epperson: An Introduction to Numerical Methods and Analysis(2/e) *John Wiley & Sons(2013)ISBN: 978-1-118-36759-9*

3 Timothy Sauer: Numerical Analysis(2/e) *Pearson (2012) ISBN: 0-321- 78367-0*

4 S S Sastri : Introductory Methods of Numerical Analysis(5/e) *PHI Learning Pvt. Ltd.(2012) ISBN:978-81-203-4592-8*

5 Ward Cheney,David Kincaid : Numerical Mathematics and Computing (6/e) *Thomson Brooks/Cole(2008) ISBN: 495-11475-8*

SIXTH SEMESTER
(ELECTIVE I)
GDMT6E01T: DIFFERENTIAL EQUATIONS

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

Aims, Objectives and Outcomes

Differential equations model the physical world around us. Many of the laws or principles governing natural phenomenon are statements or relations involving rate at which one quantity changes with respect to another. The mathematical formulation of such relations (*modeling*) often results in an equation involving derivative (*differential equations*). The course is intended to find out ways and means for solving differential equations and the topic has wide range of applications in physics, chemistry, biology, medicine, economics and engineering.

On successful completion of the course, the students shall acquire the following skills/knowledge.

COs	COURSE OUTCOMES
CO1	Students could identify a number of areas where the modeling process results in a differential equation.
CO2	They will learn what an ODE is, what it means by its solution, how to classify DEs, what it means by an IVP and so on.
CO3	They will learn to solve DEs that are in linear, separable and in exact forms and also to analyze the solution.
CO4	They will realize the basic differences between linear and non linear DEs and also basic results that guarantee a solution in each case.
CO5	They will learn a method to approximate the solution successively of a first order IVP.

Text	Elementary Differential Equations and Boundary Value Problems (11/e): William E Boyce, Richard C Diprima And Douglas B Meade *John Wiley & Sons (2017) ISBN: 1119169879*

Pre-Requisites

1.1: Some Basic Mathematical Models; Direction Fields
1.2: Solutions of some Differential equations
1.3: Classification of Differential Equations

Module-I **(20 hrs)**

2.1: Linear Differential Equations; Method of Integrating Factors
2.2: Separable Differential Equations
2.3: Modeling with First Order Differential Equations
2.4: Differences between Linear and Nonlinear Differential Equations
2.6: Exact Differential Equations and Integrating Factors
2.8: The Existence and Uniqueness Theorem *(proof omitted)*

Module-II **(20 hrs)**

3.1: Homogeneous Differential Equations with Constant Coefficients
3.2: Solutions of Linear Homogeneous Equations; the Wronskian
3.3: Complex Roots of the Characteristic Equation
3.4: Repeated Roots; Reduction of Order
3.5: Nonhomogeneous Equations; Method of Undetermined Coefficients
3.6: Variation of Parameters

Module-III **(20hrs)**

6.1: Definition of the Laplace Transform
6.2: Solution of Initial Value Problems
6.3: Step Functions
6.5: Impulse Functions
6.6: The Convolution Integral

Module-IV **(20 hrs)**

10.1: Two-Point Boundary Value Problems
10.2: Fourier Series
10.3: The Fourier Convergence Theorem
10.4: Even and Odd Functions

References:

1. Dennis G Zill &Michael R Cullen: Differential Equations with Boundary Value Problems(7/e):*Brooks/Cole Cengage Learning(2009)ISBN: 0-495-10836-7*
2. R Kent Nagle, Edward B. Saff & Arthur David Snider: Fundamentals of Differential Equations(8/e) *Addison-Wesley(2012) ISBN: 0-321-74773-9*
3. C. Henry Edwards &David E. Penney: Elementary Differential Equations (6/e) *Pearson Education, Inc. New Jersey (2008) ISBN 0-13-239730-7*
4. John Polking, Albert Boggess & David Arnold : Differential Equations with Boundary Value Problems(2/e) *Pearson Education, Inc New Jersey(2006) ISBN 0-13-186236-7*
5. Henry J. Ricardo: A Modern Introduction to Differential Equations(2/e*) Elsevier Academic Press(2009)ISBN: 978-0-12-374746-4*
6. James C Robinson: An Introduction to Ordinary Differential Equations *Cambridge University Press (2004) ISBN: 0-521-53391-0*

SIXTH SEMESTER
(Elective II)
GDMT6E02P: MATHEMATICAL PROGRAMMING WITH PYTHON AND LATEX

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80 (Practical Exam)) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	Understand basis of Python programming, apply Python programming in plotting mathematical functions, apply Python programming in numerical analysis, understands typesetting using Latex and apply Latex in writing equations

Text	Python for Education - Learning Maths and Physics using Python: Ajith Kumar B.P *Inter University Accelerator Centre 2010*

Course Contents

The course has Theory Part (*Internal evaluation*) and Practical Part (*for internal and external evaluation*). A student has to maintain a practical record of the work.

Module-I **(24 hrs)**

Basics of Python Programming

Chapter 2 Programming in Python: Two modes of using Python, Interpreter Variables and Data Types, Operators and their Precedence, Python Strings, Slicing, Python Lists, Mutable and Immutable Types, Input from the Keyboard, Iteration: while and for loops, Python Syntax, Colon & Indentation, Syntax of 'for loops', Conditional Execution: if, else if and else,

Modify loops : break and continue, Line joining, Functions, Scope of variables, Optional and Named Arguments, More on Strings and Lists, split and join, Manipulating Lists, Copying Lists, Python Modules and Packages, Different ways to import, Packages, File Input/Output, The pickle module, Formatted Printing, Exception Handling, Turtle Graphics.

Chapter 3 Arrays and Matrices: The NumPy Module Vectorized Functions.

(sec. 2.1 to 2.19, 3.1 to 3.2)

Module-II **(24 hrs)**

Applications of Python Programming

Chapter 4 Data visualization: The Matplotlib Module, Plotting mathematical functions, Famous Curves, Power Series, Fourier Series, 2D plot using colors, Meshgrids, 3D Plots, Mayavi, 3D visualization, .

Chapter 6 Numerical methods: Numerical Differentiation, Numerical Integration, Ordinary Differential Equations, Polynomials, Finding roots of an equation, System of Linear Equations, Least Squares Fitting, Interpolation.

(sec. 4.1 to 4.6, 4.8 to 4.10, 6.1 to 6.8)

Module-III **(32 hrs)**

Latex

Chapter 5 Typesetting using LATEX: Document classes, Modifying Text, Dividing the document, Environments, Typesetting Equations, Arrays and matrices, Floating bodies, Inserting Images, Example, Application

(sec. 5.1 to 5.8)

External Examination (Practical)

The external examination is a practical examination of 2½ hr duration.

The Practical Examinations will be conducted by 2 examiners (One External and One Internal).

The Practical examination has 3 sections ; 3 python programmes (from the list given below) and 1 latex document preparation(based on the syllabus).

A practical examination, based on following topics, should be conducted for the external evaluation.

Python Programmes

1. Bisection Method
2. Newton-Raphson Method
3. Numerical differentiation
4. Trapezoidal rule
5. Simpson's rule
6. Euler Method to solve ODE
7. Second order RK Method to solve ODE
8. Fourth order RK Method to solve ODE
9. Lagrange Interpolation
10. Newton's Interpolation
11. Matrix inversion
12. Gauss elimination
13. Gauss-Siedel Method

One document to be prepared using Latex.

References:

1	Saha, Amit: Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More*!*. *No Starch Press, 2015*.
2	Nunez-Iglesias, Juan, Stefan van der Walt, and Harriet Dashnow: "Elegant SciPy: The Art of Scientific Python." (2017).
3	Stewart, John M.: Python for scientists. *Cambridge University Press, 2017*.
4	Kinder, Jesse M., and Philip Nelson: A student's guide to Python for physical modeling. *Princeton University Press, 2018*.
5	McGreggor, Duncan :. Mastering matplotlib. *Packt Publishing Ltd, 2015*
6	Lamport, Leslie. LaTeX: A Document Preparation System(2/e) *Pearson Education India, 1994.*
7	Grätzer, George: Math into LATEX. *Springer Science & Business Media, 2013*
8	Hahn, Jane: LATEX for Everyone. *Prentice Hall PTR, 1993*

SIXTH SEMESTER
(Elective III)
GDMT6E03T: TOPOLOGY OF METRIC SPACES

Lecture Hours: 80 (5 Hrs/Week) **Credits: 4**
Marks: 100(Internal: 20, External: 80) **Examination: 2½ Hours**

COs	COURSE OUTCOMES
CO1	Perform simple theoretical analysis involving sets in metric and topological spaces and maps between these spaces
CO2	Apply these concepts to other areas of mathematics

Text	Metric Spaces: *Mícheál Ó Searcóid Undergraduate Mathematics Series Springer-Verlag Lo don Limited (2007) ISBN: 1-84628-369-8*

Module-I **(25 hrs)**

Chapter 1: Metrics

1.1: Metric Spaces

1.3: Metric Subspaces and Metric Superspaces

1.4: Isometries

1.6: Metrics on Products

1.7: Metrics and Norms on Linear Spaces-*[example 1.7.8 omitted]*

Chapter 2: Distance

2.1: Diameter

2.2: Distances from Points to Sets

2.3: Inequalities for Distances

2.4: Distances to Unions and Intersections

2.5: Isolated Points

2.6: Accumulation Points

2.7: Distances from Sets to Sets

Chapter 3 Boundary

3.1: Boundary Points

3.2: Sets with Empty Boundary

3.3: Boundary Inclusion

3.6: Closure and Interior

3.7: Inclusion of Closures and Interiors

Module-II **(25 hrs)**

Chapter 4 Open, Closed and Dense subsets

4.1 : Open and Closed Subsets

4.2 : Dense Subsets

4.3 : Topologies

4.4 : Topologies on Subspaces and Super spaces

4.5 : Topologies on Product Spaces

Chapter 5 Balls

5.1: Open and Closed Balls

5.2: Using Balls

Module-III **(30hrs)**

Chapter 6 Convergence

6.1: Definition of Convergence for Sequences

6.2: Limits

6.4: Convergence in Subspaces and Superspaces

6.6: Convergence Criteria for Interior and Closure

6.7: Convergence of Subsequences

6.8: Cauchy Sequences

Chapter 7 Bounds

7.1: Bounded Sets

7.4: Spaces of Bounded Functions

7.6: Convergence and Boundedness

7.7: Uniform and Pointwise Convergence

References:

1. E.T.Copson: Metric Spaces *Cambridge University Press(1968)ISBN:0 52135732 2*
2. Irving Kaplansky: Set Theory and Metric Spaces *Allyn and Bacon,Inc. Boston(1972)*
3. S. Kumaresan: Topology of Metric Spaces *Alpha Science International Ltd.(2005) ISBN: 1-84265-250-8*
4. Wilson A Sutherland: Introduction to Metric and Topological Spaces(2/e) *Oxford University Press(2009)ISBN:978-0-19-956308-1*
5. Mohamed A. Khamsi and William A. Kirk: An Introduction to Metric Spaces and FixedPoint Theory *John Wiley & Sons, Inc(2001) ISBN 0-471-41825-0*

OPEN COURSE
FIFTH SEMESTER
(OPEN COURSE)
(For students not having Mathematics as Core Course)

GMAT5D01T: APPLIED CALCULUS

Lecture Hours: 48 (3 Hrs/Week) **Credits: 3**
Marks: 75(Internal: 15, External: 60) **Examination: 2 Hours**

COs	COURSE OUTCOMES
CO1	Identify the independent and dependent variables of a function and compute its domain and range.
CO2	Evaluate functions given by formulas at given points
CO3	Plot the graphs of straight lines and conics
CO4	Compute limits
CO5	Check continuity
CO6	Compute derivatives and write down the equation of the tangent line
CO7	Determine whether the function is increasing or decreasing using derivatives
CO8	Compute velocity and acceleration
CO9	Compute marginal cost/revenue/profit of production
C10	Compute differential and use it to approximate the error occurred
CO11	Perform implicit differentiation
CO12	Compute convexity, concavity and points of inflection
CO13	Sketch curves
CO14	Determine extreme values
CO15	Determine the level of elasticity and use it for predicting the behaviour of revenue/cost/profit
CO16	Combine the techniques of model building with optimization techniques
CO17	Use exponential/logarithmic function to compute compound interest, radioactive decay etc
CO18	To compute the area under a curve, average value of a function using integration
CO19	Integrate using substitution
CO20	To estimate the future and present value of an income flow
CO21	To compute the survival and renewal functions
CO22	To compute anti derivative
CO23	To determine population density
CO24	To find the area and volume of surface of revolution

Text	Calculus: For Business, Economics, and the Social and Life Sciences BRIEF (10/e): Laurence D. Hoffmann, Gerald L. Bradley *McGraw-Hill(2010) ISBN: 978–0–07–353231–8*

Module I **(16 hrs)**

Chapter1:- Functions, Graphs, and Limits

1.1: Functions

1.2: The Graph of a Function1.3: Linear Functions

1.4 : Functional Models

1.5 : Limits

1.6 : One sided limits and continuity

Chapter2:- Differentiation: Basic Concepts

2.1 : The Derivative

2.2 : Techniques of Differentiation

2.3 : Product and quotient rules: Higher order derivatives *[proof of product and quotient rules omitted]*

2.4 : The Chain rule *[proof of general power rule omitted]*

Module II **(18 hrs)**

2.5 : Marginal Analysis and Applications using increments2.6: Implicit Differentiation and Related Rates

Chapter3:- Additional Applications of Derivative

3.1: Increasing and Decreasing Functions; Relative Extrema,

3.2: Concavity and Points of Inflection

3.4: Optimization; Elasticity of Demand

3.5: Additional Applied Optimization

Chapter4: Exponential and Logarithmic Functions

4.1: Exponential functions; continuous compounding

4.2: Logarithmic functions

Module III **(14 hrs)**

Chapter5:- Integration

5.1: Antidifferentiation: The Indefinite Integral

5.2: Integration by Substitution

5.3: The Definite Integral and the Fundamental Theorem of Calculus *[only statement of FTC required;Justification given at the end of the section omitted]*

5.5 : Additional Applications to Business and Economics

5.6 : Additional Applications to the Life and Social Sciences *[The derivation of volume formula omitted;only the formula and its applications required]*

References:

1. Soo T Tan: Applied Calculus for the Managerial, Life, and social sciences(8/e) *CengageLearning(2011) ISBN: 978-0-495-55969-6*
2. Ron Larson : Brief Calculus *An Applied Approach(8/e) Houghton Mifflin Company(2009)ISBN:978-0-618-95847-4*
3. Stefan Waner, Steven R. Costenoble: Finite Mathematics and Applied Calculus (5/e) *Brooks/ColeCengage Learning (2011) ISBN: 978-1-4390-4925-9*
4. Frank C. Wilson, Scott Adamson: Applied Calculus *Houghton Mifflin Harcourt PublishingCompany (2009)*
5. Geoffrey C. Berresford, Andrew M. Rockett: Applied Calculus(7/e) *Cengage Learning (2016)ISBN:978-1-305-08531-2*

FIFTH SEMESTER

(OPEN COURSE)

(For students not having Mathematics as Core Course)

GMAT5D02T: DISCRETE MATHEMATICS FOR BASIC AND APPLIED SCIENCES

Lecture Hours: 48 (3 Hrs/Week) **Credits: 3**
Marks: 75(Internal: 15, External: 60) **Examination: 2 Hours**

COs	COURSE OUTCOMES
CO1	Identify correct and incorrect arguments
CO2	Understand the criteria for the evaluation of arguments
CO3	Understand the scientific way of decision making using the laws of logic
CO4	Understand the concept of algebraic structures in Mathematics
CO5	Identify a given algebraic structure as belonging to a particular family of structures and to state the characteristic properties of the members of the family
CO6	Understand the concept of groups and derive basic theorems on groups
CO7	Define the concept of Boolean algebra as an algebraic structure and list its properties
CO8	Understand the applications of Boolean algebra in switching circuits
CO9	Define a Graph and identify different classes of graphs
C10	Understand various applications of Graph theory

Text	Discrete Mathematics; Proofs, Structures and Applications (3/e): *Rowan Garnier & John Taylor CRC Press, Taylor & Francis Group (2009) ISBN: 978-1-4398-1280-8(hardback)/978-1-4398-1281-5 (eBook - PDF)*

Module I **(14 hrs)**

Chaper-1 Logic

1.1 : Propositions and Truth Values

1.2 :Logical Connectives and Truth Tables- *Disjunction, Conditional Propositions, Bi conditionalPropositions*

1.3 :Tautologies and Contradictions

1.4 :Logical Equivalence and Logical Implication- *More about conditionals*

1.5: The Algebra of Propositions- *The Duality Principle, Substitution Rule*

1.6: Arguments

1.7 :Formal Proof of the Validity of Arguments

1.8 :Predicate Logic- *The Universal Quantifier, The Existential Quantifier, Two-Place Predicates,Negation of Quantified Propositional Functions*

1.9 :Arguments in Predicate Logic- *Universal Specification* (*US*), *Universal Generalization* (*UG*), *Existential Specification* (*ES*), *Existential Generalization* (*EG*)

Module II **(16 hrs)**

Chapter-8 Algebraic Structures

8.1: Binary Operations and Their Properties

8.2: Algebraic Structures- *Semigroups*

8.3 : More about Groups

8.4 : Some Families of Groups- *Cyclic Groups, Dihedral Groups, Groups of Permutations*

8.5 : Substructures

8.6 : Morphisms

Chapter 10 Boolean Algebra

10.1 : Introduction

10.2 : Properties of Boolean Algebras

10.3 : Boolean Functions

10.4 : Switching Circuits

10.5 : Logic Networks

10.6 : Minimization of Boolean Expressions

Module II **(18 hrs)**

Chapter 11 Graph Theory

11.1: Definitions and Examples

11.2: Paths and Cycles

11.3: Isomorphism of Graphs

11.4: Trees

11.5 : Planar Graphs *[proof of Euler formula omitted]*

11.6 : Directed Graphs

Chapter 12 Applications of Graph Theory

12.2 : Rooted Trees

12.3 :Sorting

12.4 :Searching Strategies

References:

1 Edward R. Scheinerman: Mathematics *A Discrete Introduction(3/e) Brooks/Cole, Cengage Learning(2013)ISBN: 978-0-8400-4942-1*

2 Gary Haggard, John Schlipf, Sue Whitesides: Discrete Mathematics for Computer Science *Thomson Brooks/Cole(2006)ISBN:0-534-49601-x*

3 D P Acharjya, Sreekumar: Fundamental Approach to Discrete Mathematics *New Age International Publishers (2005) ISBN:* ***978-81-224-2304-4***

4 Gary Chartrand ,Ping Zhang: Discrete Mathematics *Waveland Press,Inc (2011)ISBN: 978-1-57766-730-8*

5 Tom Jenkyns, Ben Stephenson: Fundamentals of Discrete Math for Computer Science *A Problem- Solving Primer Springer-Verlag London (2013) ISBN: 978-1-4471-4068-9*

6 Faron Moller, Georg Struth: Modelling Computing *Systems Mathematics for Computer ScienceSpringer-Verlag London (2013) ISBN 978-1-84800-321-7*

FIFTH SEMESTER

(OPEN COURSE)

(For students not having Mathematics as Core Course)

GMAT5D03T: LINEAR MATHEMATICAL MODELS

Lecture Hours: 48 (3 Hrs/Week) **Credits: 3**
Marks: 75(Internal: 15, External: 60) **Examination: 2 Hours**

COs	COURSE OUTCOMES
CO1	the students will be able to Understand the idea of slope of the lines, understand to find solution of Linear Systems by the Echelon Method and Gauss Jordan method
CO2	Gets an idea of matrices, understand how to add, subtract and multiplication of matrices and understand how find the inverse of a matrix
CO3	Understand the methods of solving linear programming problems geometrically and understands the drawbacks of geometric methods and to solve LP problems more effectively using Simplex method
CO4	Understand duality theory, a theory that establishes relationships between linear programming problems of maximization and minimization

Text	Finite Mathematics and Calculus with Applications (9/e) *Margaret L. Lial, Raymond N. Greenwell & Nathan P. Ritchey* Pearson Education, Inc(2012) ISBN: 0-321-74908-1

Module I **(18 hrs)**

Chapter-1 Linear Functions

1.1: Slopes and Equations of Lines
1.2: Linear Functions and Applications
1.3: The Least Squares Line

Chapter-2 Systems of Linear Equations and Matrices

2.1: Solution of Linear Systems by the Echelon Method
2.2: Solution of Linear Systems by the Gauss-Jordan Method
2.3: Addition and Subtraction of Matrices
2.4: Multiplication of Matrices
2.5: Matrix Inverses
2.6: Input-Output Models

Module II **(12 hrs)**

Chapter-3 Linear Programming: The Graphical Method

3.1 : Graphing Linear Inequalities
3.2 : Solving Linear Programming Problems Graphically
3.3 : Applications of Linear Programming

Module III **(18 hrs)**

Chapter-4 Linear Programming: The Simplex Method

4.1: Slack Variables and the Pivot
4.2 : Maximization Problems
4.3 : Minimization Problems; Duality
4.4 : Nonstandard Problems

References:

1 Soo T Tan: Finite Mathematics For the Managerial, Life, and social sciences (11/e) *CengageLearning(2015) ISBN: 1-285-46465-6*

2 Ronald J. Harshbarger, James J. Reynolds: Mathematical Applications for the Management, Life, and Social Sciences (9/e) *Brooks/Cole Cengage Learning(2009) ISBN: 978-0-547-14509-9*

3 Stefan Waner, Steven R. Costenoble: Finite Mathematics and Applied Calculus (5/e) *Brooks/ColeCengage Learning(2011) ISBN: 978-1-4390-4925-9*

4 Seymour Lipschutz, John J. Schiller, R. Alu Srinivasan: Beginning Finite Mathematics *Schaum'sOutline Series, McGraw-Hill(2005)*

5 Howard L. Rolf: Finite Mathematics *Enhanced Edition*(7/e) *Brooks/Cole, Cengage Learning (2011)ISBN:978-0-538-49732-9*

6 Michael Sullivan: Finite Mathematics An Applied Approach(11/e*) John Wiley & Sons, Inc (2011)ISBN: 978-0470-45827-3*

FIFTH SEMESTER
(OPEN COURSE)
(For students not having Mathematics as Core Course)

GMAT5D04T: MATHEMATICS FOR DECISION MAKING

Lecture Hours: 48 (3 Hrs/Week) **Credits: 3**
Marks: 75(Internal: 15, External: 60) **Examination: 2 Hours**

COs	COURSE OUTCOMES
CO1	The student could understand the classifications of data. Student is also introduced to various data collection techniques
CO2	Student will learn to visualize various types of data with the use of frequency charts and appropriate graphs
CO3	Student understands concepts like measures of central tendency, measures of variation and measures of position
CO4	Student gets a clear understanding of basic probability concepts. Student learns conditional probability, addition rule and other basic theories in probability
CO5	Student will learn various probability distributions of discrete and continuous variables
CO6	Student learns about the normal distribution, which is an important continuous probability distribution in inferential statistics
CO7	Student understands the standard normal distribution and learns the conversion of normal variable to standard normal variable

Text	Elementary Statistics: Picturing the World (6/e) *Ron Larson & Betsy Farber Pearson Education, Inc(2015) ISBN: 978-0-321-91121-6*

Module I **(16 hrs)**

Chapter1 Introduction to Statistics

1.1: An Overview of Statistics

1.2: Data Classification

1.3: Data Collection and Experimental Design

Chapter2 Descriptive Statistics

2.1: Frequency Distributions and their Graphs

2.2: More Graphs and Displays

2.3: Measures of Central Tendency

2.4: Measures of Variation

2.5: Measures of Position

Module II **(16 hrs)**

Chapter3 Probability

3.1 : Basic Concepts of Probability and Counting

3.2 : Conditional Probability and the Multiplication Rule3.3: The Addition Rule

3.4 : Additional topics in probability and counting

Module III **(16 hrs)**

Chapter4 Discrete Probability Distribution

4.1 : Probability Distributions

4.2 : Binomial Distributions

4.3 : More Discrete Probability Distributions

References:

1. Mario F. Triola: Elementary Statistics(13/e) : *Pearson Education, Inc(2018) ISBN: 9780134462455*
2. Neil A. Weiss: Elementary Statistics(8/e) *Pearson Education, Inc(2012) ISBN: 978-0-321-69123-1*
3. Nancy Pfenning: Elementary Statistics: Looking at Big Picture *Brooks/ColeCengage Learning(2011) ISBN: 978-0-495-01652-6*
4. Frederick J Gravetter, Larry B. Wallnau: Statistics for the Behavioral Sciences (10/e) *Cengage Learning(2017) ISBN: 978-1-305-50491-2*
5. Seymour Lipschutz, John J. Schiller, R. Alu Srinivasan: Beginning Finite Mathematics *Schaum's Outline Series, McGraw-Hill(2005)*
6. Michael Sullivan: Finite Mathematics An Applied Approach(11/e*) John Wiley & Sons, Inc(2011)ISBN: 978-0470-45827-3*