**Board of Studies in Mathematics and Statistics**

**MAR IVANIOS COLLEGE, THIRUVANANTHAPURAM**
**(An Autonomous College Affiliated to the University of Kerala)**

# First Degree Programme in MATHEMATICS under Choice Based Credit and Semester System

**REVISED SYLLABUS**
2015 **admission**

## First Degree Programme in Mathematics

### Programme Objective

The first degree programme in Mathematics aims to fulfil the following broad objectives.

1. Provide students with a thorough knowledge of fundamental mathematical facts.
2. To enhance the students reasoning, analytical and problem solving skills.
3. Adequately prepare students to pursue further studies in mathematics and research.
4. To prepare graduates with the capabilities to teach the mathematics curriculum at the higher secondary level.
5. To encourage students to uphold scientific integrity and objectivity in professonal endeavors.

### Programme Overview

The first degree programme in Mathematics is a choice based credit and semester system of six semesters. Each semester is of 18 weeks' duration, with a total of 450 contact hours of instruction including end semester examinations. The minimum number of credits required for the completion of the programme is 120. The different study components and the number of courses under each component are as follows:

| Study component | No. of courses |
|---|---|
| English | 5 |
| Additional language | 4 |
| Foundation courses | 2 |
| Core courses | 13 |
| Open course | 1 |
| Elective course | 1 |
| Project/Dissertation | 1 |
| Complementary course I | 4 |
| Complementary course II | 4 |

The courses engaged by the faculty of Mathematics are the following:

### Foundation Course 2

Foundation Course 2 is a basic course, offered in the second semseter.

### Core courses

Core courses are offered in all semesters except semester 2. There are 13 core courses, including practicals. All the courses have end semester examinations at the end of the respective semseters.

**Complementary Courses**

Mathematics Complemetary courses are offered to students of the disciplines of Physics, Chemistry, and Economics from Semester 1 to Semester 4.
For Mathematics Students Statistics and Physics are the complementary courses. The structure of Statistics course is given below.

**Complementary Course in Statistics for First Degree Programme in Mathematics**

| Course Code | Sem. | Title of Course | Contact hrs/week | No. of Credits |
|---|---|---|---|---|
| AUST 131.2c | 1 | Descriptive Statisics and Introduction to Probability | $2+2$ | 2 |
| AUST 231.2c | 2 | Random Variables | $2+2$ | 2 |
| AUST 331.2c | 3 | Probability Disributions and Theory of Estimation | $3+2$ | 3 |
| AUST 431.2c | 4 | Testing of Hypotheses and Analysis of Variance | $3+2$ | 3 |
| AUST 43PI.2c | 4 | Practical using Excel | | 4 |

**Open/Elective Courses**

There shall be one open course in the fifth semester and one elective course in the sixth semester. The mathematics students can opt one open course from other Departments.

General Structure of the First Degree Programme in Mathematics

| Sem | Course Code | Course title | Instr.hrs. per week | Credit | Evaluation | | Total Credit |
|---|---|---|---|---|---|---|---|
| | | | | | Int. | Ext. | |
| I | AUEN111 | English 1 | 5 | 4 | | | |
| | | Addl. Language 1 | 4 | 3 | | | |
| | AUEN121 | Foundation Course 1 | 4 | 2 | | | |
| | AUMM141 | Core Course 1 | 4 | 4 | 20% | 80% | 17 |
| | AUST131.2c | I Comple. Course 1 | 2+2 | 2 | | | |
| | AUPY131.2c | II Comple. Course 1 | 2+2 | 2 | | | |
| II | AUEN211 | English 2 | 4 | 3 | | | |
| | AUEN212 | English 3 | 5 | 4 | | | |
| | | Addl. Language 2 | 4 | 3 | | | |
| | AUMM221 | Foundation Course 2 | 4 | 3 | 20% | 80% | 17 |
| | AUST231.2c | I Comple. Course 2 | 2+2 | 2 | | | |
| | AUPY231.2c | II Comple. Course 2 | 2+2 | 2 | | | |
| III | AUEN311 | English 4 | 5 | 4 | | | |
| | | Addl. Language 3 | 5 | 4 | | | |
| | AUMM341 | Core Course 2 | 5 | 4 | 20% | 80% | 18 |
| | AUST331.2c | I Comple. Course 3 | 5 | 3 | | | |
| | AUPY331.2c | II Comple. Course 3 | 3+2 | 3 | | | |
| IV | AUEN411 | English 5 | 5 | 4 | | | |
| | | Addl. Language 4 | 5 | 4 | | | |
| | AUMM441 | Core Course 3 | 5 | 4 | 20% | 80% | 26 |
| | AUST431.2c | I Comple. Course 4 | 3+2 | 3+4 | | | |
| | AUPY431.2c | II Comple. Course 4 | 3+2 | 3+4 | | | |
| V | AUMM541 | Core Course 4 | 5 | 4 | | | |
| | AUMM542 | Core Course 5 | 4 | 3 | | | |
| | AUMM543 | Core Course 6 | 3 | 3 | 20% | 80% | 19 |
| | AUMM544 | Core Course 7 | 3 | 3 | | | |
| | AUMM545 | Core Course 8 | 5 | 4 | | | |
| | AUMM581. | Open Course | 3 | 2 | | | |
| | | Project | 2 | | | | |
| VI | AUMM641 | Core Course 9 | 5 | 4 | | | |
| | AUMM642 | Core Course 10 | 4 | 3 | | | |
| | AUMM643 | Core Course 11 | 3 | 3 | 20% | 80% | 23 |
| | AUMM64 | Core Course 12 | 3 | 3 | | | |
| | AUMM64PI | Core Course 13 | 5 | 4 | | | |
| | AUMM691. | Elective Course | 3 | 2 | | | |
| | | Project | 2 | 4 | | | |

## Structure of Core Courses

| Sem | Course Code | Course title | Instr.hrs. per week | Credit |
|---|---|---|---|---|
| I | AUMM 141 | Methods of Mathematics | 4 | 4 |
| II | AUMM 221 | Foundations of Mathematics | 4 | 3 |
| III | AUMM 341 | Algebra and Calculus-I | 5 | 4 |
| IV | AUMM 441 | Algebra and Calculus-II | 5 | 4 |
| V | AUMM 541 | Real Analysis-I | 5 | 4 |
| | AUMM 542 | Complex Analysis I | 4 | 3 |
| | AUMM 543 | Differential Equations | 3 | 3 |
| | AUMM 544 | Vector Analysis | 3 | 3 |
| | AUMM 545 | Abstract Algebra I | 5 | 4 |
| | AUMM 581. | Open Course | 3 | 2 |
| | | Project | 2 | |
| VI | AUMM 641 | Real Analysis-II | 5 | 4 |
| | AUMM 642 | Linear Algebra | 4 | 3 |
| | AUMM 643 | Complex Analysis II | 3 | 3 |
| | AUMM 644 | Abstract Algebra II | 3 | 3 |
| | AUMM 64PI | Computer Programming (Pract.) | 5 | 4 |
| | AUMM 691. | Elective Course | 3 | 2 |
| | | Project | 2 | 4 |

## Structure of Open Courses

One of the following courses will be chosen as open course.

| Sem | Course Code | Course title | Instr.hrs. per week | Credit |
|---|---|---|---|---|
| V | AUMM 581.a | Actuarial Science | 3 | 2 |
| V | AUMM 581.b | Business Mathematics | 3 | 2 |
| V | AUMM 581.c | Operations Research | 3 | 2 |

## Structure of Elective Courses

One of the following courses will be chosen as elective course.

| Sem | Course Code | Course title | Instr.hrs. per week | Credit |
|---|---|---|---|---|
| VI | AUMM 691.a | Fuzzy Mathematics | 3 | 2 |
| VI | AUMM 691.b | Graph Theory | 3 | 2 |
| VI | AUMM 691.c | Mechanics | 3 | 2 |

## Structure of the Complementary Courses

Complementary Course in Mathematics for First Degree Programme in Physics

| Course Code | Sem. | Title of Course | Contact hrs/week | No. of Credits |
|---|---|---|---|---|
| AUMM 131.2d | 1 | Differentiation and Analytic Geometry | 4 | 3 |
| AUMM 231.2d | 2 | Integration, Power series and Linear Algebra | 4 | 3 |
| AUMM 331.2d | 3 | Vectors and Differential Eqs. | 5 | 4 |
| AUMM 431.2d | 4 | Complex Analysis,Theory of Eqs., Fourier Series and Transforms | 5 | 4 |

Complementary Course in Mathematics for First Degree Programme in Chemistry

| Course Code | Sem. | Title of Course | Contact hrs/week | No. of Credits |
|---|---|---|---|---|
| AUMM 131.2b | 1 | Differentiation and Analytic Geometry | 4 | 3 |
| AUMM 231.2b | 2 | Integration, Power series and Linear Algebra | 4 | 3 |
| AUMM 331.2b | 3 | Vectors and Differential Eqs. | 5 | 4 |
| AUMM 431.2b | 4 | Theory of Eqs., Abstract Algebra, and Linear Transformations | 5 | 4 |

Complementary Course in Mathematics for First Degree Programme in Economics

| Course Code | Sem. | Title of Course | Contact hrs/week | No. of Credits |
|---|---|---|---|---|
| AUMM 131.1a | 1 | Mathematics for Economics I | 3 | 2 |
| AUMM 231.1a | 2 | Mathematics for Economics II | 3 | 3 |
| AUMM 331.1a | 3 | Mathematics for Economics III | 3 | 3 |
| AUMM 431.1a | 4 | Mathematics for Economics IV | 3 | 3 |

## Evaluation and Grading

The Evaluation of each Course shall consists of two parts.

1. Continuous Evaluation(CE)
2. End Semester Evaluation(ESE)

The CE and ESE ratio shall be 1:4 for both Courses with or without practical. There shall be a maximum of 80 marks for ESE and maximum of 20 marks for CE. For all Courses(Theory and Practical) Grades are given on a 7-point scale based on the total percentage of mark(CE+ESE) as given below.
Criteria for Grading

| Percentage of marks | CCPA | Letter Grade |
|---|---|---|
| 90 and above | 9 and above | A+ Outstanding |
| 80 to $<$ 90 | 8 to $<$ 9 | A Excellent |
| 70 to $<$ 80 | 7 to $<$ 8 | B Very Good |
| 60 to $<$ 70 | 6 to $<$ 7 | C Good |
| 50 to $<$ 60 | 5 to $<$ 6 | D Satisfactory |
| 40 to $<$ 50 | 4 to $<$ 5 | E Adequate |
| Below | $<$ 4 | F Failure |

Pattern of Questions

| Question Type | Total No. of Questions | No. of Questions to be answered | Marks for each Question | Total Marks |
|---|---|---|---|---|
| Very short answer type | 10 | 10 | 1 | 10 |
| Short answer | 12 | 8 | 2 | 16 |
| Short essay | 9 | 6 | 4 | 24 |
| Long essay | 4 | 2 | 15 | 30 |
| Total | 35 | 26 | | 80 |

Continuous Evaluation
The components of the continuous evaluation are given below.

| Componet | Mark |
|---|---|
| Attendance | 5 marks |
| Assignment/Seminar | 5 marks |
| Test Paper | 10 marks |

The marks of a Course are consolidated by combining the marks of ESE and CE (80+20). A minimum of 40% marks (E Grade )is required for passing a Course with a separate minimum of 40%(E Grade) for Continuous Evaluation and End Semester Evaluation.

# Mar Ivanios College, Thiruvananthapuram
# Syllabus for the First Degree Programme in Mathematics

## Semester I
## Methods of Mathematics

CODE: AUMM 141 Instructional hours per week: 4

No.of credits: 4

**Module I Algebra**

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

In this part of the course, we study the basic properties of natural numbers, traditionally called *Theory of Numbers*. It is based on Chapters 2–5 of the text. Students should be encouraged to read the textbook and try to do the problems on their own, to gain practice in writing algebraic proofs. All the problems and exercises at the end of each section are to be discussed.

We start with the methods of proofs by induction, as in Sections A and B of Chapter 2. The intuitive idea that these methods give a scheme of extending a result from one natural number to the next *independent of the number under consideration* should be stressed. The fact that the second principle is easier in some cases should be illustrated through examples such as Example 1 of Section B. *The logical equivalence of these two methods (Theorems 1 and 2 of Section B) need not be discussed.*

We then pass onto THE WELL ORDERING PRINCIPLE, as in Section C. Example E1, Theorem 1 and Proposition 3 should be discussed with proofs based on this principle. *The deduction of this principle from the principle of induction, as in Theorem 2, need not be done.* Thus the two principles of induction and the well-ordering principle need only be discussed as intuitively obvious properties of natural numbers.

Before introducing the DIVISION THEOREM, as in Section D, the usual process of long division to get the *quotient* and *remainder* must be recalled through examples and the formal proof of this theorem should be linked to these examples. After proving the this theorem and the UNIQUENESS PROPOSITION as in this section, the representation of natural numbers in different bases can be explained as in Section E. *The last section of Chapter 2 on operations in different bases (Section F) need not be discussed.*

The idea of the GREATEST COMMON DIVISOR of two natural numbers, studied in elementary class, is to be recalled next and the *existence* of a such a number justified, as in Section A of Chapter 3. The idea of *coprimality* is also to be considered here. Some of the important properties of coprime numbers, as in Exercises E9, E10 and E11 must be discussed. Next, EUCLID'S ALGORITHM and some of its applications are to be discussed, as in Section B. After discussing the theoretical consequences of Euclid's Algorithm, namely *Bezout's Identity* and its corollaries, as in Section C, its practical use in solving indeterminate equations of the first degree is to be discussed, as in the text. (See also `http://en.wikipedia.org/wiki/Diophantine_equation`) *The last two sections of this chapter on the efficiency of Euclid's Algorithm (Section D) and on incommensurability (Section E) need not be discussed.*

A discussion on primes and THE FUNDAMENTAL THEOREM ON ARITHMETIC, as given in the first three section of Chapter 4 are to be done next. *The last section of this chapter on primes in an interval need not be discussed.*

Finally we introduce the new idea of congruences as in Chapter 5. The fact that when an integer is divided by another, the dividend is congruent to the remainder modulo the divisor should be emphasized. In discussing the basic properties of congruences the fact that the cancellation of common factors does not hold in general for congruences should be emphasized and illustrated through examples. This part of the course is based on Sections A, B, C of Chapter 5.

**Module 2 Calculus**

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, the basic ideas of differentiation of real valued functions are considered. It is based on Chapters 1–3 of the text.

We start with the intuitive idea of a function as the dependence of one quantity on another as in the subsection titled FUNCTIONS of Section 1.1 of the text and pass on to Definitions 1.1.1 and 1.1.2. We next discuss basic properties of functions, as in Section 1.2. It must be emphasized through illustrations that not all equations connecting two variables give one variable as a function of the other, as in Example 1 of Section 1.2 of the text. (The notion of *explicit* and *implicit* definitions of functions and their graphs, as given in the first two parts of Section 3.6 can be discussed here itself.) Functions defined piecewise and their graphs must be specially mentioned and illustrated. Approximate solutions to problems through graphical methods are to be explained as in Example 7 of the section. Section 1.3 on using computers may be skipped, but the use of computers in plotting graphs should be demonstrated, using Open Source Software such as GeoGebra or Gnuplot.

(See also `http://www-groups.dcs.st-and.ac.uk/~history/Curves/Curves.html`)

Some of the ideas in Section 1.4, such as arithmetic operations on functions, maybe familiar to the students, but they should be reviewed. Other ideas such as symmetry, stretching and compression and translation maybe new and should be emphasized. Section 1.5 named LINES maybe supplemented with Appendix C, COORDINATE PLANES AND LINES. *Section 1.6 on families of functions and Section 1.7 on mathematical modelling need not be discussed.* But parametric equations, especially that of the cycloid, must be discussed in detail, as in Section 1.8.

Limits and continuity are concepts introduced in Higher Secondary class. In this course, the intuitive description of of these ideas are to be reinforced through tabulation and plotting and illustrated through examples, as in Sections 2.1–2.3. *The rigorous description of limits, as in Section 2.4, need not be discussed.* Sections 2.5 and 2.6 on continuity must be discussed.

The notion of differentiation is also familiar to the students. Here, this idea is to be re-introduced through applications as in the first two sections of Chapter 3.

(See also `http://en.wikipedia.org/wiki/History_of_calculus`) The discussion of VELOCITY AND SLOPES at the beginning of Section 3.1 maybe based on Example 1 of Section 2.1, instead of the unfamiliar bell-pulling example. Much of the material in Sections 3.3–3.7 maybe already seen, but they should be reviewed, emphasizing the graphical meaning and applications. The idea of implicit differentiation should be made clear, as in Section 3.6. *The last section on approximations, Section 3.8, need not be discussed.*

**Module 3 Analytic Geometry**

Text: Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

This part of the course is a detailed discussion on conics, based on Sections 11.4 and 11.5 of the text. Students are introduced to the standard equation of the conics in the Higher Secondary class, but little else on conics. Here we start with the geometrically unified description of conics as sections of a cone, as in the subsection conic sections of Section 11.4 of the text (see also `http://en.wikipedia.org/wiki/Conic_sections`) and pass on to the description subsection DEFINITION OF THE CONIC SECTIONS. Various problems in EXERCISE SET 11.4 on practical applications of conics should be discussed. Theorem 11.6.1 and the discussions following it are to be discussed next. (The connection between the description of conics as sections of cone and using the focus-directrix property can be in `http://en.wikipedia.org/wiki/Dandelin_spheres`) Finally, the geometric and algebraic description of conics tilted with respect to the coordinate axes are discussed as in Section 11.5, culminating in Theorem 11.5.2 characterizing the graphs of all second degree equations in two variables.

The final aim of this part is to give a complete characterization of graphs of second degree equations in two variables as given in Theorem 11.5.2, thus giving an algebraically unified description of conics.

REFERENCES:


1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. S.Lang, *A first Calculus*, Springer.


Distribution of instructional hours:

Module 1: 24 hours; Module 2: 36 hours; Module 3: 12 hours

## Semester II

### Foundations of Mathematics

CODE: AUMM 221 — Instructional hours per week: 4

No.of credits: 3

#### Module I Algebra

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

We continue the study of the theory of numbers, based on parts of Chapters 5–7 and Chapters 9–10 of the text. (Chapter 8, discussing abstract ideas is postponed to the next semester.)

We start with Sections D and E of Chapter 5, which discuss more properties and applications of the idea of congruence introduced in the first semester course. We then pass on to the idea of congruence classes and related ideas, as in Chapter 6 of the text. The notion of Congruence modulo $m$, done in the first semester, is now introduced as an equivalence relation and the congruence classes modulo $m$ are discussed through examples such as $\mathbb{Z}/2\mathbb{Z}$ and $\mathbb{Z}/12\mathbb{Z}Z$ (clock arithmetic), leading to the general set $\mathbb{Z}/m\mathbb{Z}$. Here we can recall the ideas of equivalence relation (learnt in Higher Secondary class) and partition and the relation between the two. The sections named RATIONAL NUMBERS, EQUIVALENCE CLASSES and NATURAL NUMBERS of Chapter 1 should be used to supplement this discussion. As applications, only Section A of Chapter 7 on ROUND ROBIN TOURNAMENTS and Section C on TRIAL DIVISION need be discussed.

Next we move on to Fermat's and Euler's Theorems, as in Chapter 9. Only the first four sections of this chapter need be done. (The other sections are to be discussed in the next semester.) In Section C, exercises E7–E10 on the computation of Euler's phi function must be done and used to compute the phi-value of some specific numbers see also Bernard and Child, *Higher Algebra*. As an applications, only FINDING HIGHER POWERS MODULO $m$ (Section D of Chapter 9, see also `http://en.wikipedia.org/wiki/RSA`), RSA CODES Mersenne Numbers and Fermat Numbers (Section C of Chapter 10) need be done.

#### Module 2 Calculus

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part, we continue the discussion on calculus and analytic geometry started in the first semester. It is based on parts of Chapters 4–8 and Chapter 11 of the text.

We start with the discussion on how the derivative of a function can be used to visualize the graph of the function in better detail, as described in Sections 4.1–4.3 of the text. We then discuss how the ideas of maxima and minima can be used to solve practical problems, as in Section 4.5. *Sections 4.4, 4.7 and 4.8 need not be discussed.*

We next introduce the idea of integration as anti-differentiation, as in Definition 5.2.1. As motivation for this idea, the first two subsections, FINDING POSITION AND VELOCITY BY INTEGRATION and UNIFORMLY ACCELERATED MOTION of Section 5.7 can be used. *The lat two subsections of Section 5.2,* INTEGRATION FROM THE VIEWPOINT OF DIFFERENTIAL EQUATIONS *and* DIRECTION FIELDS*, need not be discussed.* After completing Sections 5.2 and 5.3, we turn to the area problem, as in Section 5.1. We pass on to the subsections DEFINITION OF AREA and NET SIGNED AREA of Section 5.4. Only Definitions 5.4.3 and 5.4.5 of this section and the discussions preceding these need be discussed. We then discuss the subsection RIEMANN SUMS AND THE DEFINITE INTEGRAL of Section 5.5. Only Definition 5.5.1 and Theorems 5.5.4 and 5.5.5 of this section need be discussed. The connection between anti-differentiation and Riemann integration is to be discussed next, as in the subsection THE FUNDAMENTAL THEOREM OF CALCULUS of Section 5.6. *The proof of Theorem 5.6.1 and the remaining parts of this section need not be discussed.* But Sections 5.7 and 5.8 are to be discussed in full. Applications of integration comes next, as in Sections 6.1–6.5 of the test. *Sections 6.6 and 6.7 need not be discussed.*

Though the idea of inverse functions is introduced in the Higher Secondary class, this has to be done in a more thorough manner as in Section 7.1. Also, the ideas have to be graphically interpreted. Before discussing the exponential and logarithmic functions, the idea of irrational exponents has to be made clear, as in Section 7.2. After Section 7.3 on differentiation and integration of the exponential and logarithmic functions, Section 7.6 on inverse trigonometric functions, Section 7.7 on LH́ospital's Rule and Section 7.8 on hyperbolic functions are to be done in full. *Sections 7.4 and 7.5 need not be discussed.*

Various techniques of integration are to be considered next, as in Sections 8.1–8.5. Then improper integrals are to be discussed as in Section 8.8. *The other sections, 8.6 and 8.7 need not be discussed.*

**Module 3 Analytical Geometry**

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, we introduce polar coordinates as in Section 11.1 of the text. Areas in polar coordinates are to be done as in Section 11.3 and the polar equations of conics as in Section 11.6. The subsection APPLICATIONS IN ASTRONOMY must also be discussed.

REFERENCES:

1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.

2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.

3. S.Lang, *A first Calculus*, Springer.

Distribution of instructional hours:

Module 1: 24 hours; Module 2: 36 hours; Module 3: 12 hours

# Semester III

## Algebra and Calculus I

CODE: AUMM 341 Instructional hours per week: 5

No.of credits: 4

**Module I Algebra**

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

Continuing the discussion on number theory in the first two semesters, here we make first contact with the part of mathematics currently called *Abstract Algebra*. It is based on parts of Chapters 8, 9, and 12 of the text.

Contrary to the usual stand-alone courses on abstract algebra, we introduce rings before groups, since the former arise naturally as generalizations of number systems. Sections A and B of Chapter 8, (including the problems) are to be discussed in full. *In section C, the definition of characteristic and the rest of the portions need not be discussed*. More examples of rings and exercises on homomorphism can be given to get a clear idea of the concepts.

Next comes a discussion on the units of the ring of congruence classes leading to the definition of an abstract group and then the GROUP OF UNITS of an abstract ring, as in Section E and Section F of Chapter 9. This culminates in the ABSTRACT FERMAT'S THEOREM, as in Section E. *The proofs of generalized associativity or generalized commutativity need not be discussed*. But the fact that a set $G$ with an associative multiplication is a group, if it either has the identity and inverse properties or has the cancellation and solvability properties has to be proved (see T. W .Hungerford, *Algebra*). The exponent of an Abelian group, as in Section 9F also has to be discussed. As an illustration of the interplay between number theory and abstract algebra, we consider the THE CHINESE REMAINDER THEOREM, as in Section A of Chapter 12. Only the first part and the problems E1, E2, E3 and E4 of this section need be discussed , *The alternate method of reducing all the congruences to one need not be considered*. As another application, the multiplicative property of the phi function discussed earlier must be redone (Corollary 3 of Section C). The square roots of 1 modulo some integer, as in Section C of Chapter 12 must also be discussed.

REFERENCES:


1. J B Fraleigh, *A First Course in Abstract Algebra*, Narosa Publications
2. I N Herstein, *Topics in Algebra*, Vikas Publications
3. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications
4. D A R Wallace, *Groups, Rings and Fields*, Springer
5. Jones and Jones, *Number Theory*, Springer

**Module 2 Analytic Geometry**

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, we consider equations of surfaces and curves in three dimensions. It is based on Chapter 12 of the text.

Students have had an introduction to analytic geometry in three dimensions, such as the equations to planes and lines, and to vectors in their Higher Secondary Classes. These must be reviewed with more illustrations. Here the aid of a plotting software becomes essential. The Free Software GNUPLOT mentioned earlier has such 3D capabilities. (see also `http://mathworld.wolfram.com/topics/Surfaces.html`)

After discussing SPHERES and CYLINDRICAL SURFACES as in Section 12.1, We pass on to a discussion of VECTORS, as in Section 12.2. The physical origins of the concept must be emphasized as in the subsection, VECTORS IN PHYSICS AND ENGINEERING. The definition of vector addition can be motivated by the discussion given in the subsection, RESULTANT OF CONCURRENT FORCES which may be familiar to students from their high school physics. All the sections of the chapter are to be discussed in the same spirit, emphasizing both the physical and geometrical interpretations.

**Module 3 Calculus**

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Here we extend the operations of differentiation and integration to *vector valued functions* of a real variable, based on Chapter 13 of the text.

All sections of this Chapter must be discussed, with emphais on geometry and physics, as in the text. The problems given in various exercise sets should be an essential part of the course. Exercises 17 (a) and 17 (b) of Exercise Set 13.5 on curvature of plane curves and some of its applications in the subsequent exercises must be discussed in detail.

REFERENCES:


1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. S.Lang, *A first Calculus*, Springer.


Distribution of instructional hours:

Module 1: 36 hours; Module 2: 27 hours; Module 3: 27 hours

# Semester IV

## Algebra and Calculus II

CODE: AUMM 441 Instructional hours per week: 5

No.of credits: 4

**Module I Algebra**

Text : Lindsay N. Childs, *A Concrete Introduction to Higher Algebra*, Second Edition, Springer

Continuing the study of rings in the last semester, here we introduce polynomials as another example. This part of the course is based on Chapters 14, 15 and parts of Chapter 16 of the text.

After reviewing the idea of polynomials studied in High School, we introduce polynomials over a commutative ring. The distinction between polynomial as an algebraic expression and polynomial as a function should be emphasized, as in the section POLYNOMIALS AND FUNCTIONS of Chapter 14. All sections of Chapters 14 and 15 are to be discussed.

We then briefly consider irreducible polynomials with real coefficients. After discussing the dependence of irreducibility on the field of coefficients as in the beginning of Chapter 16, we pass on to Section C. The reducibility of polynomials of degree greater than 2 over real numbers must be mentioned, but *Euler's proof for degree 4 need not be discussed*. The fact that the root of a polynomial gives a factor leads to the consideration of roots as in Section E. (*Complex numbers, as in Section D need not be discussed here.*) The origin of complex numbers in the study of cubic equations must be emphasized. (See also, Paul J Nahin, *An Imaginary Tale: The Story of* $\sqrt{-1}$) The unsolvability of higher degree polynomials by radicals, mentioned at the end of this section, must be noted. The FUNDAMENTAL THEOREM OF ALGEBRA must next be discussed. *This theorem need not be proved*, but Euler's real version (COROLLARY 1) must be proved based on this, as in the text.

REFERENCES:


1. J B Fraleigh, *A First Course in Abstract Algebra*, Narosa Publications
2. I N Herstein, *Topics in Algebra*, Vikas Publications
3. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications
4. D A R Wallace, *Groups, Rings and Fields*, Springer
5. Jones and Jones, *Number Theory*, Springer

**Module 2 Calculus**

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

In this part of the course, we consider the calculus of functions of two variables. It is based on Chapter 14 and Chapter 15 of the text. The geometric interpretation of the ideas should be emphasized throughout, with the aid of plotting software such as Gnuplot.

After a discussion of functions of two variable and their graphs, as in the first section of Chapter 14, we discuss the concepts of limit and continuity of such functions. We then move on to a discussion of differentiation of functions of two variables, as in Sections 14.1–14.3, 14.5 and 14.8–9. *Section 14.4 on differentiability and differentials and Section 14.6 on directional derivatives and Section 14.7 on tangent planes need not be discussed.*

Integration in space is to be done as in Sections 1–5 of Chapter 15. *The last three sections of Chapter 15 need not be discussed.*

REFERENCES:


1. James Stewart, *Essential Calculus*, Thompson Publications, 2007.
2. Thomas and Finney,*Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
3. S.Lang, *A first Calculus*, Springer.


Distribution of instructional hours:

Module $1$: $36$ hours; Module $2$: $54$ hours

# Semester V

## Real Analysis I

CODE: AUMM 541 Instructional hours per week: 5

No.of credits: 4

Text : R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, Third Edition, Wiley

In this course, we discuss the notion of real numbers and the ides of limits in a formal manner. Many of the topics discussed in this course were introduced somewhat informally in earlier courses, but in this course, the emphasis is on mathematical rigor. It is based on Chapters 2–4 of the text.

In teaching this course, all ideas should be first motivated by geometrical considerations and then deduced algebraically from the axioms of real numbers as a complete ordered field. Also, the historical evolution of ideas, both in terms of physical necessity and mathematical unity should be discussed. Thus the course emphasizes the dialectic between practical utility and logical rigor in general, and within mathematics, that between geometric intuition and algebraic formalism.

Throughout the course, examples and exercises in the text should be used to illustrate the ideas discussed. Students should be encouraged to do problems on their own, to gain practice in writing rigorous proofs.

### Module 1

The first step is to make precise the very concept of number and the rules for manipulating numbers. The course can start with a historical overview of how different kinds of numbers were constructed in different periods in history, depending on the physical or mathematical needs of the age. (See for example, the three articles on real numbers at `www-groups.dcs.st-and.ac.uk/~history/Indexes/Analysis.html`) A discussion on how real numbers are conceived as lengths and hence as points on a line should follow this. The efforts to approximate irrational numbers by rational numbers, in the familiar instances such as $\sqrt{2}$ and $\pi$ can lead to the modern decimal representation and this gives semi-rigorous definitions of operations on real numbers.

The realization of the set $\mathbb{R}$ of real numbers as a field can be introduced at this stage and compared with the set $\mathbb{Q}$ of rational numbers, as in 2.1.1–2.1.4 of the textbook. The idea of order in $\mathbb{Q}$ and $\mathbb{R}$ must be introduced next, as in 2.1.5–2.1.13 of the textbook. The notion of absolute value and that of a neighborhood, as in 2.2.1–2.2.9 of the textbook comes next.

The discussion of the COMPLETENESS PROPERTY OF $\mathbb{R}$ requires some care. The version given in 2.3.6 of the text is highly counter-intuitive as an axiom. Instead, Instead the following version due to Dedekind can be used:

*If the set of real numbers is split into two non-empty sets such that every number in one set is less than every number in the other, then either the first set contains a least number or the second set contains a largest number*

And this can be easily interpreted geometrically as a line considered as a set of points. (See R. Dedekind, *Essays on The Theory of Numbers*, available as a freely downloadable e-book at `http://www.gutenberg.org/etext/21016`) The SUPREMUM PROPERTY of $\mathbb{R}$ can easily *proved* as a consequence of this axiom.

It should be emphasized at this point that in this course, the only assumptions we make about $\mathbb{R}$ are the axioms of a complete ordered field and every definition we make would be given in terms of these and every result we propose would be deduced from these axioms (and the theorems proved earlier). The remaining part of Section 2.3 and Section 2.4 in full are to be discussed as in the test. *In Section 2.5, the subsections,* THE UNCOUNTABILITY OF $\mathbb{R}$, BINARY REPRESENTATIONS, DECIMAL REPRESENTATIONS, PERIODIC DECIMALS *and* CANTOR'S SECOND PROOF *need not be discussed*.

**Module 2**

We then pass on to the idea of limits of sequences and series, as in Chapter 3 of the text. It should be supplemented by Sections 10.2 and 10.4 of the calculus text by Anton (used in earlier semesters) to provide motivation, illustrative examples and more exercises.

**Module 3**

Limits of functions are to be discussed as in Chapter 4 of the text. Before introducing the rigorous definition of limits, the informal description of these ideas through graphs, as done in the earlier calculus courses should be recalled. Also, the various theorems should be illustrated through examples and exercises given in the text. Plotting software such as Geogebra can be used to plot the various functions discussed in Chapter 4.

References

1. A. D. ALEXANDROV et al., *Mathematics:Its Content, Methods and Meaning*, Dover
2. R. DEDEKIND, *Essays on The Theory of Numbers*, available as a freely dowloadable e-book at `http://www.gutenberg.org/etext/21016`)
3. W. RUDIN, *Principles of Mathematical Analysis*, Second Edition, McGraw-Hill
4. A. E. TAYLOR, *General Theory of Functions and Integration*, Dover

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

# Semester V

## Complex Analysis I

CODE: AUMM 542 Instructional hours per week: 4

No.of credits: 3

Text : Joseph Bak and Donald J. Newman, *Complex Analysis*. Third Edition, Springer

In this course, we discuss the basic properties of complex numbers and extend the notions of differentiation and integration to complex functions. It is based on Chapters 1–4 of the text. Examples and exercises in the text forms an integral part of the course.

### Module 1

The basic operations on complex numbers are familiar to the students from their Higher secondary course. Also, the historical motivation for complex numbers is briefly touched upon in MODULE 1 of the fourth-semester course ALGEBRA AND CALCULUS IV. So, the present course can start with a brief review of the INTRODUCTION and a discussion on the representation of complex numbers as ordered pairs of real numbers as in Section 1.1. The other sections of this chapters are to be discussed in order. *The definition of uniform convergence and* 1.9 M-TEST *in Section 1.4 need not be discussed. Also,* STEREOGRAPHIC PROJECTION *as in Section 1.5 need not be discussed*, but infinite limits should be introduced (I.11 DEFINITION). The use of complex numbers in number theory and geometry are to be illustrated using Exercises 9, 10 and 14 of this chapter.

We then pass on to the definition of complex functions, starting with polynomials as Chapter 2..The difference between a polynomial function of *two real variables* and that of *a single complex variable* should be emphasized as in the INTRODUCTION to this chapter. Also, in discussing ANOTHER WAY OF RECOGNIZING ANALYTIC POLYNOMIALS preceding 2.2 Definition, it should be noted that the field operations allow us only to define upto *rational functions* of complex numbers and that expressions like $\cos(x + iy)$ are meaningless at this stage. In discussing POWER SERIES as in Section 2.8, *the proof of* 2.8 THEOREM *and the comment following the proof about uniform convergence need not be discussed*. Examples 1–3 following this are to be emphasized as signifying the behaviour of different power series *on* the circle of convergence. The remainig part of Chapter 2 should be discussed in full.

### Module 2

In Chapter 3 on ANALYTIC FUNCTIONS, *the proof of 3.2 Proposition on the sufficiency of Cauchy-Riemann Equations for analyticity need not be done*. Except for this, Chapter 3 must be done in full. Exercises 21–23 on the power series expansions of the exponential function and the sine and cosine functions must also be discussed in detail.

**Module 3**

In Chapter 4, the definition of the integral of $f$ along $C$ (4.3 DEFINITION of the text) should be motivated as limit of the Riemann sums of the form $\sum f(z_k)(z_k - z_{k-1})$ (see for example, the MIT OPENCOURSEWARE video of LECTURE 5 of PART I CALCULUS under CALCULUS REVISITED). *In Section 4.1, the result on the integral of uniform limit* (4.11 PROPOSITION) *need not be discussed*. Section 4.2 is to be discussed in full.

References


1. JAMES BROWN AND RUEL CHURCHILL, *Complex Variables and Applications*, Eighth Edition, McGraw-Hill

2. J. M. HOWIE, *Complex Analysis* Springer


DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

# Semester V

## Differential Equations

CODE: AUMM 543 — Instructional hours per week: 3

No.of credits: 3

Texts : 1. Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

2. Erwin Kreyszig, *Advanced Engineering Mathematics*, Eigth Edition, Wiley-India

In this course, we discuss how differential equations arise in various physical problems and consider some methods to solve first order differential equations and second order linear equations. It is based on parts of Chapters 5 and 9 of [1] and Chapter 2 of [2].

### Module 1

In this module we discuss first order equations and is based on [1]. We start with some simple examples of physical situatons in which differential equations arise, using some of the examples of Section 9.3. This is to be followed by the last two subsections of Section 5.2, INTEGRATION FROM THE VIEWPOINT OF DIFFERENTIAL EQUATIONS and DIRECTION FIELDS includeing problems related to these ideas from EXERCISE SET 5.2. We next consider first order differential equations as in Sections 9.1–9.3. Then we discuss EXACT DIFFERENTIAL EQUATIONS as in Section 1.5 of [2].

### Module 2

Second order linear differential equations are discussed in this module and it is based on Chapter 2 of [2]. More precisely, Sections 2.1–2.3 and Sections 2.4–2.11 must be done in detail, including relevant problems. *Section 2.3 on* DIFFERENTIAL OPERATORS *need not be discussed*

References


1. G. F. SIMMONS, *Differential Equations with applications and Hystorical notes*, Tata McGraw-Hill, 2003

2. PETER V. O' NEIL, *Advanced Engineering Mathematics*, Thompson Publications, 2007


DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

# Semester V

## Vector Analysis

CODE: AUMM 544 | Instructional hours per week: 3

No.of credits: 3

Text : Howard Anton, et al, *Calculus*, 7th Edn, John Wiley

In this course, we consider some advanced parts of vector calculus. It is based on parts of Chapter 14 and Chapter 16 of the text. The physical motivation and interpretation of the various mathematical concepts should be emphasized throughout, as in the text.

### Module 1

We begin with the notion of directional derivatives as in Section 14.6. *The last subsection on derivative of a function of several variables need not be discussed*. We then pass on to the definition of a vector field and its divergence and curl, as in Section 16.1. The del and Laplacian operators must also be discussed. We next discuss line integrals, as in Section 16.2 and then conservative vector fields, as in Section 16.3. This module of the course ends with a discussion of Green's Theorem, as in Section 16.4.

### Module 2

In this module, we introduce the notion of a surface integral and discuss Gauss's Theorem and Stoke's Theorem and their applications, as in Sections 16.5–16.8 of the text

References:


1. Thomas and Finney, *Calculus and Analytic Geometry*, Ninth Edition, Addison-Wesley.
2. Kreyzig, *Advanced Engineering Mathematics*, $8^{\text{th}}$ edition, John Wiley.
3. Peter V. O' Neil, *Advanced Engineering Mathematics*, ThompsonPublications, 2007
4. Michael D. Greenberg, *Advanced Engineering Mathematics*, PearsonEducation, 2002.


DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

# Semester V

## Abstract Algebra I

CODE: AUMM 545 — Instructional hours per week: 5

No.of credits: 4

Text : John B. Fraleigh, *A First Course in Abstract Algebra*. Seventh Edition, Narosa

Students introduced to some elements of Abstract Algebra in Semester IV are now ready to do it rigorously. In this course, we discuss the basics of abstract group theory, based on Sections 2–10 of the text.

Students should be given training to write proofs and to do problems, based on axioms. The recommended text contains lots of examples and exercises. Most of the problems in this text are computational and hence the student can try them as assignments with proper guidance of the teacher.

### Module 1

The course begins with section 0, which can be reviewed quickly. *The subsection on* CARDINALITY *need not be discussed*. We then move on to Section 2 on binary relations (*skipping Section 1*. The ideas of *binary operation on a set*, *well definedness of a binary operation* and *a set closed under a binary operation* should be emphasized. Isomorphisms of binary structures should be done in detail, as in Section 3. After recalling the idea of abstract groups introduced in the previous semester, Section 4 on groups, Section 5 on subgroups and Section 6 on cyclic groups must be done in full. *Section 7,* GENERATING SETS AND CAYLEY DIGRAPHS, *need not be discussed*.

### Module 2

We next consider the group of permutations in detail, as in Section 8–10 (Chapter II) and cosets and Lagrange's Theorem, as in Section 10. The first part of Section 11 on direct products of groups should also be discussed. *The second part,* FINITELY GENERATED ABELIAN GROUPS *and the entire Section 12,* PLANE ISOMETRIES *need not be discussed*.

REFERENCES:


1. I N Herstein, *Topics in Algebra*, Vikas Publications

2. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications

3. D A R Wallace, *Groups, Rings and Fields*, Springer


DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 45 hours; Module 2: 45 hours

# Semester V

## Actuarial Science (Open Course)

CODE: AUMM 581.$a$ | Instructional hours per week: 3
No. of Credits: 2

Module 1 : Introduction to Insurance Business: What is Actuarial Science? Concept of Risk, Role of statistics in Insurance, Insurance business in India.

Introductory Statistics: Some important discrete distributions, Some important continuous distributions, Multivariate distributions

Module 2 : Feasibility of Insurance business and risk models for short terms: Expected value principle, Notion of utility,risk models for short terms

Future Lifetime distribution and Life tables: Future life time random variable, Curate future-life time, life tables, Assumptions for fractional ages, select and ultimate life tables.

Module 3 : Actuarial Present values of benefit in Life insurance products: Compound interest, Discount factor, Benefit payable at the moment of death, Benefit payable at the end of of year of death, relation between $A$ and $\bar{A}$.

Annuities, certain, continuous life annuities, Discrete life annuities, Life annuities with $m^{th}$ly payments.

TEXT: Shylaja R. Deshmukh : Actuarial Statistics University press, Hyderabad, 2009. Chapters 1 - 6.

REFERENCES:


1. Bowers, Jr., N. L et al: *Actuarial Mathematics* , $2^{nd}$ Edition,The society of Actuaries, Illinois, Sahaumberg,1997

2. Palande, P. S. et al: *Insurance in India: Changing policies and Emerging Oppertunities* ,Response Books, New Delhi, 2003

3. Purohit, S. G. et al: *Statistics Using $R$* ,Narosa, New Delhi, 2008

4. www.actuariesindia.org


DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 12 hours; Module 2: 21 hours; Module 3: 21 hours

# Semester V

## Business Mathematics (Open Course)

CODE: AUMM 581.$b$ — Instructional hours per week: 3
No. of Credits: 2

Module 1 Basic Mathematics of Finance: Nominal rate of Interest and effective rate of interest, Continuous Compounding, force of interest, compound interest calculations at varying rate of interest, present value, interest and discount, Nominal rate of discount, effective rate of discount, force of discount, Depreciation.

(Chapter 8 of Unit I of text- Sections: 8.1, 8.2, 8.3, 8.4. 8.5, 8.6, 8.7, 8.9)

Module 2 Differentiation and their applications to Business and Economics: Meaning of derivatives, rules of differentiation, standard results (basics only for doing problems of chapter 5 of Unit 1) ( Chapter 4 of unit I of text- Sections: 4.3, 4.4, 4.5, 4.6 )

Maxima and Minima, concavity, convexity and points of inflection, elasticity of demand, Price elasticity of demand (Chapter 5 of Unit I of text - Sections: 5.1, 5.2, 5.3, 5.4, 5.5. 5.6, 5.7)

Integration and their applications to Business and Economics: Meaning, rules of integration, standard results, Integration by parts, definite integration (basics only for doing problems of chapter 7 of Unit 1 of text) (Chapter 6 of unit I of text: Sections: 6.1, 6.2, 6.4, 6.10, 6.11)

Marginal cost, marginal revenue, Consumer's surplus, producer's surplus, consumer's surplus under pure competition, consumer's surplus under monopoly (Chapter 7 of unit I of text- Sections: 7.1, 7.2, 7.3, 7.4, 7.5)

Module 3 Index Numbers: Definition, types of index numbers, methods of construction of price index numbers, Laspeyer's price index number, Paasche's price index number, Fisher ideal index number, advantages of index numbers, limitations of index numbers

(Chapter 6 of Unit II of text- Sections: 6.1, 6.3, 6.4, 6.5, 6.6, 6.8, 6.16, 6.17)

Time series: Definition, Components of time series, Measurement of Trend (Chapter 7 of Unit II of text - Sections: 7.1, 7.2, 7.4)

TEXT: B M Aggarwal: Business Mathematics and Statistics Vikas Publishing House, New Delhi, 2009

REFERENCES:

1. Qazi Zameeruddin, et al : *Business Mathematics* , Vikas Publishing House, New Delhi, 2009

2. Alpha C Chicny, Kevin Wainwright: *Fundamental methods of Mathematical Economics* ,Mc-Graw Hill, Singapre, 2005

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

# Semester V

## Operations Research (Open Course)

CODE: AUMM 581.$c$ Instructional hours per week: 3
No. of Credits: 2

Module 1 LINEAR PROGRAMMING: Formulation of Linear Programming models, Graphical solution of Linear Programs in two variables, Linear Programs in standard form - basic variable - basic solution- basic feasible solution -feasible solution, Solution of a Linear Programming problem using simplex method (Since Big-M method is not included in the syllabus, avoid questions in simplex method with constraints of $\geq$ or $=$ type.)

Module 2 TRANSPORTATION PROBLEMS: Linear programming formulation - Initial basic feasible solution (Vogel'sapproximation method/North-west corner rule) - degeneracy in basic feasible solution - Modified distribution method - optimalitytest.

ASSIGNMENT PROBLEMS: Standard assignment problems - Hungarian method for solving an assignment problem.

Module 3 PROJECT MANAGEMENT: Activity -dummy activity - event - project network, CPM (solution by network analysis only), PERT.

TEXT: Ravindran - Philips - Solberg: Operations Research- Principles and Practice

REFERENCE:

Hamdy A Taha: *Operations Research*

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

# Semester VI

## Real Analysis II

CODE: AUMM 641 — Instructional hours per week: 5

No.of credits: 4

Text : R. G. Bartle, D. R. Sherbert, *Introduction to Real Analysis*, Third Edition, Wiley

This course builds on the first course in Real Analysis done earlier and concentrates on real valued functions. We discuss the three properties of continuity, differentiability and Riemann integrability. The history of how calculus developed must also be discussed (see `en.wikipedia.org/wiki/History_of_calculus`, for example).

### Module 1

The intuitive geometric notion of continuity as an unbroken curve seen in the calculus course must be recalled and then the discussion should gradually lead to the $\epsilon$-$\delta$ definition, as an effort to make this notion formal and rigorous. The connexion between continuity and existence of limit should be emphasized. The material contained in Sections 5.1–5.3 and Section 5.6 of the textbook forms the core of this part of the course. *Section 5.4,* UNIFORM CONTINUITY *and Section 5.5,* CONTINUITY AND GAUGES, *need not be discussed.*

### Module 2

Differentiation and integration are extensively discussed in an earlier Calculus course, with a strong emphasis on computation. Here we take another look at differentiation from a conceptual point of view. It is based on Chapter 6 of the textbook. All the four sections of this chapter are to be discussed in detail.

### Module 3

In this module, we discuss Riemann's theory of integration. It is based on Sections 7.1–7.3 of the text. *Section 7.4,* APPROXIMATE INTEGRATION *need not be discussed.*

Students have already seen integration as anti-differentiation and informally as the limit of sums in the calculus couse. All these idea are made more precise here. The historical evolution of the ideas leading to Riemann integral can be found in `en.wikipedia.org/wiki/Integral#History`. The differences between anti-differentiation and Riemann's theory of integration should be stressed. Section 7.3 of the textbook must be seen as establishing the links between anti-differntiation and Riemann integration, Examples 7.3.2(e) and 7.3.7(a), (b) are significant in this context.

References


1. A. D. Alexandrov et al., *Mathematics:Its Content, Methods and Meaning*, Dover

2. R. Dedekind, *Essays on The Theory of Numbers*, available as a freely dowloadable e-book at `http://www.gutenberg.org/etext/21016`)

3. W. Rudin, *Principles of Mathematical Analysis*, Second Edition, McGraw-Hill

4. A. E. Taylor, *General Theory of Functions and Integration*, Dover


Distribution of instructional hours:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

# Semester VI

## Linear Algebra

CODE: AUMM 642 | Instructional hours per week: 4

No.of credits: 3

Text : Thoma Banchoff and John Wermer, *Linear Algebra Through Geometry*, Second Edition, Springer

In this course we introduce the basics of linear algebra and matrix theory with emphasis on their geometrical aspects. It is based on the Chapters 1–4 of the text.

### Module 1

In this module we bring together some aspects of analytic geometry of two dimensions, solutions of simultaneous in two unknowns and theory of $2 \times 2$ matrices under the unified theme of linear transformations of the plane. It is based on Chapters 1 and 2 of the text.

### Module 2

The ideas in the first module are extended to three dimensional space in this module. It is based on Chapter 3 of the text

### Module 3

The concepts discussed in the first two modules are generalized to arbitrary dimensions in this module. It is based on Chapter 4 of the text.

TEXT: References:

1. T S Blyth and E F Robertson: *Linear Algebra*, Springer, Second Ed.

2. R Bronson and G B Costa: *Linear Algebra*, Academic Press, Seond Ed.

3. David C Lay: *Linear Algebra*, Pearson

4. K Hoffman and R Kunze: *Linear Algebra*, PHI

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 24 hours; Module 2: 24 hours; Module 3: 24 hours

# Semester VI

## Complex Analysis II

CODE: AUMM 643 — Instructional hours per week: 3

No.of credits: 3

Texts 1. Joseph Bak and Donald J. Newman, *Complex Analysis*. Third Edition, Springer

2. James Brown and Ruel Churchill, *Complex Variables and Applications*, Eighth Edition, McGraw-Hill

In this course, we consider some of the basic properties of functions analytic in a disc or on a punctured disc. It is based on parts Chapters 6, 9, 10, 11 of [1] and Chapters 6 and 7 of [2].

### Module 1

We start with Sections 6.1 and 6.2 of [1]. In Section 6.1, *only the statement of* 6.5 POWER SERIES REPRESENTATION FOR FUNCTIONS ANALYTIC IN A DISC *need be given; the proof need not be discussed*. But it should be linked to 2.10 COROLLAY to note that a function analytic in a disc is infinitely differentiable in it and with 2.11 COROLLARY to see how the coefficients of the series are related to the derivatives of the function. *Section 6.3 need not be discussed*.

We then pass on to a discussion of isolated singular points and residues, as in Chapter 6 (Sections 68–77). *Here and elsewhere, all examples and exercises involving logarithms must be skipped*.

### Module 2

In this module, we consider the application of the Residue Theorem in the evaluation of some integrals. as in Chapter 7 of [2]. Only Sections 78–82 and Section 85 need be discussed. *Sections 83–84 and Sections 86–89 need not be considered*.

Section 11.2 of [1], APPLICATION OF CONTOUR INTEGRAL METHODS TO EVALUATION AND ESTIMATION OF SUMS, must also be discussed, along with the relevant exercises in this section.

REFERENCES:


1. Ahlfors, L. V, *Copmlex Analysis*, McGraw-Hill, 1979.

2. J M Howie, *Complex Analysis*, Springer


DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

# Semester VI

## Abstract Algebra II

CODE: AUMM 544 — Instructional hours per week: 3

No.of credits: 3

TEXT: John B. Fraleigh, *A First Course in Abstract Algebra*. Seventh Edn, Narosa

In this course, we discuss more of group theory and also the basics of ring theory. It is based on parts of Chapters II–V of the text. As in the first course, due emphasis must be given to problem solving.

### Module 1

In this part of the course, we discuss homomorphism of groups and factor groups, as in Sections 13–15 of the text. *The last two parts of Section 15,* SIMPLE GROUPS *and* THE CENTER AND COMMUTATOR SUBGROUPS *need not be discussed.*.

### Module 2

We start by recalling the definition of rings, seen in an earlier course on algebra. Then Sections 18-20 must be discussed in detail. *Sections 21–25 need not be discussed*, But Section 26 on homomorphisms and factor rings must be done in full.
REFERENCES:


1. I N Herstein, *Topics in Algebra*, Vikas Publications
2. J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications
3. D A R Wallace, *Groups, Rings and Fields*, Springer


DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 27 hours; Module 2: 27 hours

# Semester VI

## Computer Programming (Practicals)

CODE: AUMM $64PI$ Instructional hours per week: 5

No.of credits: 4

In this course, we teach document preparation in computers using the LaTeX typesetiing program and also the basics of computer programming using Python. Since the operatig system to be used is GNU/Linux, fundamentals of this OS are also to be discussed.

### Module 1

Text : Matthias Kalle Dalheimer and Matt Welsh, *Running Linux*, Fifth Edition, O'Reilly

In this module, we consider the fundamentals of the GNU/Linux operating system. It is based on Chapter 4, BASIC UNIX COMMANDS AND CONCEPTS, of the text. Students should be taught about the Linux directory structure and the advantages of keeping their files in well structured directories. Since they will be using the command line interface most of the time, this entails facility in using such commands as `mkdir`, `pwd`, `cd`, `ls`, `cp`, `mv`, `ls` and so on.

### Module 2

Text : *LaTeX Tutorials—A Primer* by Indian TeX Users Group

In this module, we discuss computer typesetting using LaTeX, Chapters 1–2 of the text must be discussed in full. On bibliography, only the first section of Chapter 3 need be discussed. Also, only the first section of Chapter 4—on table of conetents–need be done. Chapters 6–9 are to be done in full. Finally Chapter 12 also is to be discussed in full.

### Module 3

Text : Vernon L. Ceder, *The Quick Python Book*, Second Edition, Manning

It is based on Chapters 3–9 of the text. The concepts in Chapters 3–8 must be discussed in full, but in Chapter 9, only Sections 9.1–9.5 need be discussed.

The programs done in class should all have a mathematical content. Some possibilities are listed below:

- Factorial of a number
- Checking primality of a number

- Listing all primes below a given number
- Prime factorization of a number
- Finding all factors of a number
- GCD of two numbers using the Euclidean Algorithm
- Finding the multiples in Bezout's Identity

DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 30 hours; Module 2: 30 hours; Module 3: 30 hours

## Semester VI

### Fuzzy Mathematics (Elective)

CODE: AUMM 691.$a$ Instructional hours per week: 3
No. of credits: 2

Module 1 FROM CRISP SETS TO FUZZY SETS: A PARADIGM SHIFT.Introduction-crisp sets: an overview-fuzzy sets: basic types and basic concepts of fuzzy sets, Fuzzy sets versus crisp sets, Additional properties of cuts, Representation of fuzzy sets.

Module 2 OPERATIONS ON FUZZY SETS AND FUZZY ARITHMETIC:Operations on fuzzy sets-types of operations, fuzzy complements, fuzzy intersections, t-norms, fuzzy unions, t-conorms.

Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals, Arithmetic operations on fuzzy numbers.

Module 3 FUZZY RELATIONS :Crisp versus fuzzy relations, projections and cylindric extensions, Binary fuzzy relations, Binary relations on a single set, Fuzzy equivalence relations.

TEXT: George J Klir and Yuan: Fuzzy sets and fuzzy logic: Theory and applications, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
Chapter 1: Sections 1.1 to 1.4
Chapter 2: Sections 2.1 and 2.2
Chapter 3: Sections 3.1 to 3.4
Chapter 4: Sections 4.1 to 4.4
Chapter 5: Sections 5.1 to 5.5

References:

1. Klir G J and T Folger: *Fuzzy sets, Uncertainty and Information*, PHI Pvt.Ltd., New Delhi, 1998

2. H J Zimmerman: *Fuzzy Set Theory and its Applications*, Allied Publishers, 1996.

3. Dubois D and Prade H: *Fuzzy Sets and Systems: Theory and Applications*, Ac.Press, NY, 1988.

Distribution of instructional hours:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

# Semester VI

## Graph Theory (Elective)

CODE: AUMM 691.$b$ Instructional hours per week: 3
No. of credits: 3

Overview of the Course: The course has been designed to build an awareness of some of the

fundamental concepts in Graph Theory and to develop better understanding of the subject so as to use these ideas skillfully in solving real world problems.

Module 1 A brief history of Graph Theory: The Königsberg bridge problem, the history of the Four Colour Theorem for maps, Contributions to Graph Theory by Euler, Kirchoff, Cayley, Mobius, De Morgan, Hamilton, Erdös, Tutte, Harary, etc. (A maximum of three hours may be allotted to this sub-module. In addition to sections 1.2 and 1.6 of the text, materials for this part can be had from other sources including the internet.)Graphs: Definition of graph, vertex, edge, incidence, adjacency, loops, parallel edges, simple graph. Representation of graphs, diagrammatic representation, matrix representation (adjacency* matrix and incidence matrix only). Finite and infinite graphs, Definition of directed graphs, illustrative examples, Directed graphs, Applications of graphs. [sections 1.1, 1.2, 1.3, 1.4, 7.1, 9.1, 9.2 ]Degree of a vertex, odd vertex, even vertex, relation between sum of degrees of vertices and the number of edges in a graph, and its consequence: number of odd vertices in a graph is even. Isolated vertex, pendant vertex, null graph, complete graphs [page 32], bipartite graphs [page 168], complete bipartite graph [page 192-prob 8.5], regular graph, complement* of a graph, graph isomorphisms, self complementary* graphs, illustrative examples. [sections 1.4, 1.5, 2.1 ]Sub-graphs, edge disjoint sub-graphs, spanning sub-graphs*, induced subgraphs [sections 2.2]The decanting problem and its graph model [no solution at this point]. The puzzle with multicolour cubes [problem 1.8 and section 2.3].

Module 2 Walks, open walks, closed walks, paths, circuits, end vertices of a path, path joinig two vertices, length of a path, connected and disconnected graphs. Components of a graph. [ sections 2.4, 2.5 ]Euler line, Euler graph, unicursal line, unicursal graph, characterisaion of Euler graph, Concept of Euler digraph [section 2.5, 9.5], Solution of the decanting problem. The Königsberg problem, the Chinese postman problem* and the Teleprinter's problem, their graph models and solutions. [problem 1.8 and sections 2.3, 1.2, 9.5]

Module 3 Trees- properties of trees, distance, eccentricity, center, radius, diameter, spanning tree, illustrative examples. [sections 3.1, 3.2, 3.3, 3.4, 3.7 ]Planar graphs examples of planar and non-planar graphs, different representations of a planar graph. Regular polyhedra, Euler's polyhedral formula. [Theorem 5.6, without proof] .

Illustrative examples, Kuratowski's graphs and their importance in the theory of planar graphs, forbidden sub-graph,

characterisaion of planar graph [Kuratowski's theorem, Theorem 5.9, without proof], illustrative examples-both planar and non-planar. [sections 5.2, 5.3, 5.4, 5.5] Graph theoretic version of the Four Colour Theorem, without proof.

TEXT: Narsingh Deo: Graph Theory with applications for Engineering and Computer Science, Prentice Hall of India Pvt. Ltd., 2000.
References:


1. BalakrishnanR and Ranganatahan: *A Text Book of Graph Theory*, Springer

2. Body J A and Murthy U S R:*Graph Theory with Applications*, The Macmillan Press

3. Harary F: *Graph Theory*, Addison-Wesley

4. Vasudev C: *Graph Theory with Applications*

5. West D B: *Introduction to Graph Theory*, Prentice Hall of India Pvt. Ltd.


Note: Generally, the references are from NARSINGH DEO. Those marked with an asterisk are found elsewhere.DISTRIBUTION OF INSTRUCTIONAL HOURS:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

# Semester VI

## Mechanics (Elective)

Code: AUMM 691.$c$ Instructional hours per week: 3
No. of credits: 2

Part A: STATICS

Module 1 Introduction, composition and resolution of forces, parallelogram law of forces, triangle law of forces, Lami's theorem, polygon of forces, $\lambda-\mu$ theorem, resultant of a finite number of coplanar forces acting upon a particle, conditions of equilibrium, parallel forces, resultant of two parallel forces acting upon a rigid body, moments, moments of a force about a point and about an axis, generalized theorem of moments.

Module 2 Couples, equilibrium of a rigid body acted on by three coplanar forces, general conditions of equilibrium of a rigid body under coplanar forces, friction, laws of friction, limiting friction, coefficient of friction and simple problems.

Part B : DYNAMICS

Module 3 Velocity, relative velocity, acceleration, parallelogram laws of acceleration, motion under gravity, Newtons laws of motion and their applications to simple problems. Impulse, work, energy, kinetic and potential energies of a body, principle of conservation of energy.

Module 4 Projectiles, Range on an inclined plane, Collision of elastic bodies, Newton's experimental law, Impact of sphere on a plane, Direct and oblique impact of two spheres, Loss of kinetic energy by impact, Simple harmonic motion, Examples of simple harmonic motion, Simple pendulum.

Text: by S.L. Loney, The Elements of Statics and Dynamics, Part-I and Part-II, AITBSPublications and distributions (Regd), Delhi
Distribution of instructional hours:

Module 1: 15 hours; Module 2: 12 hours; Module 3: 15 hours, Module 4: 12 hours

# Mar Ivanios College, Thiruvananthapuram
# Syllabus for the Complementary Course in Mathematics
# for First Degree Programme in Physics

## Semester I

## Mathematics-I
## (Differentiation and Analytic Geometry)
## Code: AUMM 131.2d

Instructional hours per week: 4 No. of Credits:3

Overview

The complementary course intended for Physics students lays emphasis on the application of mathematical methods to Physics. The two modules on Calculus links the topic to the real world and the student's own experience as the authors of the text put it. Doing as many of exercises from the text should prove valuable in understanding the applications of the theory. Analytic geometry presented here is important in applications of calculus.

Module 1: Differentiation with applications to Physics-I

- Functions and Graphs :
  Functions and graphs of functions with examples from Physics. Properties of functions. New functions from old. Lines. Parametric equations and cycloids. (Some of the ideas may be familiar to the students. They should be reviewed. New ideas such as symmetry, stretching and compression, translation, parametric equations etc. should be emphasized.)
  Sections 1.1,1.2,1.3,1.5 and 1.8 of the text.

- Limit and Continuity :
  Limits. Computing Limits. Infinite limits and vertical asymptotes. Limits at infinity and horizontal asymptotes. Continuity. Limit and Continuity of Trigonometric functions.
  Sections 2.1,2.2,2.3,2.5, and 2.6 of the text.

- Derivative :
  Slope and rates of change. Derivative. Techniques of differentiation. Derivatives of Trigonometric functions. Implicit differentiation. Related rates. Local linear approximation. Differentials.
  Sections 3.1,3.2,3.3,3.4,3.5, and 3.6 of the text.

- Applications of derivative :
  Increasing and decreasing functions. Concavity. Relative Extrema, First and second derivative tests. Rectilinear motion. Absolute maxima and minima. Applied maximum anmd minimimum problems. Statement of Rolle's Theorem and Mean Value Theorem. The velocity interpretation of Mean Value Theorem. Statement of theorems 4.1.2 and 4.8.3 (consequences of the Mean Value Theorem).
  Sections 4.1,4.2,4.4,4.5,4.6 and 4.8 of the text.

- Inverse Functions :
  Inverse functions. Continuity and differentiability of inverse functions. Exponential and logarithmic functions. Derivatives of logarithmic functions and logarithmic differentiation. Derivatives of the exponential function. Inverse trigonometric functions. Derivatives of Inverse trigonometric functions.
  Sections 7.1 and relevent topics from sections 7.3 and 7.6 of the text.

- Hyperbolic Functions
  Definitions of hyperbolic functions. Graphs of hyperbolic functions. Hanging cables and other applications. Hyperbolic identities. Why they are called hyperbolic functions. Derivatives of hyperbolic functions. Inverse hyperbolic functions. Logarithmic forms of inverse hyperbolic functions. Derivatives of inverse hyperbolic functions.
  Section 7.8 of the text excluding integration part.

Module 2: Functions of Several Variables

- Functions of two or more variables. Graphs of functions of two variables. Equations of surfaces such as sphere, cylinder, cone, paraboloid, ellipsoid, hyperboloid etc. Limit and Continuity. Partial derivatives. The chain rule (various forms). Euler's theorem for homogeneous functions. Maxima and minima of functions of two variables. Use of partial derivatives in locating local maxima and minima. Lagrange method for finding maximum/minimum values of functions subject to one constraint.
  Sections 14.2,14.3,14.5,14.8 and 14.9 of the text. Also relevent topics from 14.1 and 12.7
  Exercise set 14.4; Questions 49 and 50.

Module 3: Analytic Geometry

- Conic Sections :
  Definitions of the conic sections. Equations of the conics in standard positions. Equations of the conics which are translated from standard positions vertically or horizontally. Asymptotes of a hyperbola. Reflection properties of conic sections.

- Second Degree equations in $x$ and $y$. Rotation of axes. Eliminating $xy$ - term. The Discriminant.

- Polar coordinates. Relationship between polar and rectangular coordinates.

- Conic sections in polar coordinates. Focus - Directrix Property of Conics. Eccentricity of an ellipse as a measure of flatness. Polar equations of conics. Sketching conics in polar coordinates. Kepler's Laws.
  Sections 11.4,11.5,11.1 and 11.6 of the text.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

## Semester II

## Mathematics-II
## (Integration, Power Series and Linear Algebra)

Code: AUMM 231.2d

Instructional hours per week: 4 No. of Credits: 3

Overview

The complementary course in the second semester continues the trend indicated in the first, namely, laying emphasis on applications of integral calculus and linear algebra to problems in Physics. Module 1 consists of various applications of integration techniques. It also covers multiple integrals. Modules 2 deals with infinite series which play a fundamental role in both mathematics and science. The third module covers matrix theory.

### Module 1: Applications of integration

- Review of Indefinite Integral,Integration by substituition,Definite Integral,Fundamental Theorem of Calculus and Evaluating definite integrals by substitution.
  Sections 5.2, 5.3, 5.5, 5.6, and 5.8 of the text.
- Rectilinear motion: finding position and velocity by integration. Uniformly accelerated motion. The free-fall model. Integrating rates of change. Displacement in rectilinear motion. Distance travelled in rectilinear motion. Analysing the velocity versus time curve. Average value of a continuous function. Average velocity revisited.
  Section 5.7 of the text.
- Use of definite integrals in finding area under curves, area between two curves, volume of revolution, arc length and surface area of a solid of revolution.
  Sections 6.1, 6.2, 6.4, and 6.5 of the text.
- The idea of approximating the volume under a bounded surface in 3-space by volumes of boxes, leading to the definition of double integrals of functions of two variables over bounded regions. Evaluation of double integrals by iterated integrals. Evaluation by changing to polar co-ordinates and by suitably changing order of integration in the iterated integral. Applications to finding the volume of solids under bounded surfaces.
  Sections 15.1, 15.2, and 15.3 of the text.
- Triple integrals over bounded regions in three space. Evaluation by iterated integrals. Cylindrical coordinates and spherical coordinates and their relation to Cartesian coordinates. Use of cylindrical and spherical co-ordinates in evaluating triple integrals. Applications of triple integrals to finding volumes of solid objects.
  Sections 15.5, 12.8 and 15.7 of the text.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

## Module 2: Power Series

- Maclaurin and Taylor Polynomial Approximations :
  Local quadratic approximations, Maclaurin polynomials and Taylor polynomials. The Reminder Estimation Theorem
  Section 10.1 of the text.

- Review of basic ideas of Sequences, Limit of a sequence, Series, Convergent and Divergent series, Absolute convergence and Ratio Test.
  Relevent topics from sections 10.2, 10.4, and 10.6 of the text.

- Power series and their convergence :
  Results about the region of convergence of a power series(without proof). Radius of convergence. Functions defined by a power series. Results about term by term differentiation and integration of power series (without proof). Taylor's theorem with derivative form of remainder (without proof) and its use in approximating functions by polynomials. Taylor series and Maclaurin series and representation of functions by Taylor series. Taylor series of basic functions and the regions where these series converge to the respective functions. Binomial series as a Taylor series and its convergence. Obtaining Taylor series representation of other functions by differentiaion, integration, substitution etc.
  Section 10.8 and 10.9 of the text.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

## Module 3: Linear Algebra

- A quick review of Matrices and Determinants.

- Elementary Row Operations and Elementary Matrices. Invariance of rank under elementary row operations. The Row Echelon Form of a Matrix. Proofs of theorems may be omitted.
  Section 7.2 and 7.3 of the text.

- The Vector Space $\mathbb{R}^n$ :
  $n$-vector, algebra of $\mathbb{R}^n$, subspace of $\mathbb{R}^n$, linear combination, spanning set, linear dependence and independence, basis and dimension. Only basic definitions, results and simple problems need be done.
  Relevent topics from sections 6.4 and 6.5 of the text.

- The rows and columns of a matrix as elements of $\mathbb{R}^n$ for suitable n. Rank of a matrix as the maximum number of linearly independent rows/columns. Finding the rank of a matrix by reducing to echelon form.
  Section 7.4 of the text.

- Homogeneous and non-homogeneous system of linear equations. Results about the existence and nature of solution of a system of equations in terms of the ranks of the matrices involved.
  Section 7.5 and 7.7 of the text.

- The eigen values and eigen vectors. Method of finding the eigen values and eigen vectors of a matrix.
  Section 9.1 (excluding 9.1.1) of the text

- Diagonalisable matrices. Advantages of diagonalisable matrices in computing matrix powers and solving system of equations. The result(without proof) that a square matrix of order n is diagonalisabe (i) if and only if it has n linearly independent eigen vectors (ii) if it has n distinct eigen values. Method of diagonalising a matrix. Orthogonal andsymmetric matrices.
  Section 9.2 and 9.3 of the text.

Text : Peter V. O' Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

**Semester III**

**Mathematics-III**
**(Vectors and Differential Equations)**

Code: AUMM 331.2d

Instructional hours per week:5 No. of Credits: 4

Texts

1. Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

2. Peter V. O' Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

3. K. A. Stroud, J. A. Booth, *Advanced Engineering Mathematics*, $4^{th}$ Edition, palgrave macmillan 2003.

Reference : George B. Thomas,Jr, *Thomas'Calculus*, (Eleventh Edition), Pearson,2008.

Module 1: Vector Valued Functions

- Introduction to vector-valued functions: Parametric curves in 3 space, Vector valued functions, graphs of vector valued functions
- Calculus of vector valued functions: Limits and Continuity, Derivatives and their rules, Tangent lines to graphs of vector valued functions, Derivatives of dot and cross product, Integrals of vector valued functions and their rules
- Change of Parameter; Arc length: Arc length from a vector view point and arc length as a parameter, Change of parameter, Arc length parametrizations and Properties
- Unit tangent, Normal and Binormal vectors: Unit tangent vectors, unit normal vectors, Inward unit normal vectors in 2-space, Computing T and N for curves parametrized by arc length, Binormal vectors in 3-space
- Curvature: Definition of curvature, Formulas for curvature, Radius of curvature
- Motion along a curve: Velocity, acceleration and speed, Displacement and distance travelled, Normal and tangential components of acceleration
- Directional derivatives and gradients: Directional derivatives, The Gradient, Properties of the gradient, An application of gradients
(Sections 13.1 to 13.6 and 14.6 of Text 1 )

Reference : Sections 13.1, 13.3, 13.4, 13.5, 14.5 of Reference Text

Module 2: Topics in Vector Calculus

- Vector fields: Vector fields, graphical representation of vector fields, Inverse square fields, Gradient fields, Conservative fields and potential functions, Divergence and curl, the del operator, the Laplacian operator.

- Line integrals: Line integrals and their evaluation, Line integrals in 3 space, Mass of a wire as a line integral, Arc length as a line integral, Line integrals with respect to x,y,z, Line integrals along piecewise smooth curves, Change of parameter in line integrals, reversing the direction of integration, Work as line integral, A method for calculating work.

- Independence of path, Conservative vector fields: Work integrals, independence of path, Fundamental theorem of work integrals(Statement and problems), work integral along closed path, A test for conservative vector fields, conservative vector fields in 3 space,

- Green's theorem: Greens theorem (Statement and problems), A notation for line integrals along simple closed curves, Finding area using Green's theorem.

- Surface integrals: Definition of a surface integral, Evaluating Surface integrals, Mass of a curved lamina, surface area as surface integrals.

- Application of Surface integrals, flux: Flow fields, Oriented surfaces, Evaluating flux integrals, Orientation of non parametric surfaces.

- The Divergence theorem: The Divergence theorem (Statement and problems), Using the divergence theorem to find flux, Gauss law for inverse square fields.

- Stoke's theorem: Stoke's theorem (Statement and problems), Using Stoke's theorem to calculate work, Relationship between Green's theorem and Stoke's theorem.
  (Sections 16.1 to 16.8 of Text 1)
  Reference: Sections 16.1 to 16.8 of Reference Text.
  Programmes 17 and 18 of Text 3.

Module 3: Differential equations

- First Order Differential Equations :
  Basic concepts about differential equations and their solutions. Method of solving special types of first order ODEs such as variable separable, linear, exact, homogeneous, Bournoulli, and Reccati equations. Finding the family of curves orthogonal to a given family.
  Sections 1.1, 1.2, 1.3, 1.4, 1.6, and 1.7.3 of the text 2.

- Second order differential equations :
  Preliminary Concepts. Theory of the general solution of homogeneous and non-homogeneous linear ODEs. Proofs of theorems may be omitted. However the ideas contained in the theorems must be be explained with examples.
  Sections 2.1 and 2.2 ofthe text 2

- Second order linear homogeneous ODEs with constant coefficients. The characteristic equation and its use in finding the general solution. Euler's equation.
  Section 2.4 and 2.5 of the text 2.

- Second order linear non-homogeneous ODEs. General solution as the sum of general solution of the corresponding homogeneous equation and particular integralof the given equation. The method of variation of parameters. The method of undetermined coeffients. The principle of superposition.
  Section 2.6 (only 2.6.1,2.6.2 and 2.6.3) of the text 2.

- Power series solution of Initial Value Problems (only first order equations)
  Section 4.1 of the text 2.

## Semester IV

## Mathematics-IV
## (Complex Analysis,Theory of Equations, Fourier Series and Fourier Transforms)

Code: AUMM 431.2d

Instructional hours per week: 5 No. of Credits: 4

Module 1: Theory of Equations

- Fundamental theorem of Algebra (without proof), relations between roots and coefficients of a polynomial equation, Transformation of polynomial equations and special cases.
- Cubic equations and Biquadratic equations, simple problems, finding nature of roots of polynomials without solving-Des Cartes' rule of signs,
- Remarks about necessity of numerical methods for solving polynomials of degree five and above, finding approximate roots via bisection method, by iteration, Newton-Raphson method, Modified Newton-Raphson method.
(Chapter VI of Text 1; Programme 1 of Text 2.)

Texts : 1. Barnard and Child, *Higher Algebra*, Macmillan
2. K A Stroud, *Advanced Engineering Mathematics*, $4^{th}$ edition,Palgrave, 2003

Module 2: Complex Analysis

- Review of basic concepts of complex numbers.
Chapter 1 of the text.
- Functions of a complex variable, Limits, Theorems on limits (no proof), Continuity, Derivative, differentiation Formulas, Cauchy- Riemann equations, Sufficient conditions for differentiability (no proof), Polar coordinates, Analytic functions, Examples, Harmonic congugates, Properties of analytic functions, Method of constructing an analytic function with a given harmonic function as real or imaginary part.
Chapter 2 except sections 13, 14,17, 22, 27 and 28.
- Exponential function, Logarihtmic function, Branches and derivatives of logarithms, Some identities involving logarithms,Trigonometric functions.
Chapter 3 except sections 33, 35, 36.
- Derivatives of functions $\omega(t)$, Definite integrals of functions $\omega(t)$, Contours, Contour integrals, Examples, antiderivatives, Cauchy-Goursat theorem, Simply connected domains, Multiply connected domains, Cauchy Integral formula, Extension Cauchy Integral formula, Cosequences of the extension. Problems based on the above results. Proofs of all the theorems may be omitted. However the ideas contained in the theorems must be be explained with examples.
Chapter 4 except sections 42, 43, 53, 54.
- Review of convergence of sequences , series, Taylor Series(no proof), Examples, Laurent's Series(no proof), Examples.
Chapter 5 sections 55, 56, 57, 59, 60 and 62.

- Isolated singular points, Residues, Cauchy's Resdue Theorem(no proof), Three types of Isolated singular points, Residues at poles, examples.
  chapter 6 sections 68, 69, 70, 72, 73 and 74.

- Evaluation of improper integrals, Examples, Improper integrals from Fourier analysis, Definite integrals involving sines and cosines.
  chapter 7 sections 78, 79, 80 and 85.

Text : Brown and Churchil, *Complex Variables and Applications*, McGraw-Hill Higher Education; 8 edition, 2008

Module 3: Fourier series and transforms

- Fourier series of a function, Odd and even functions, Convergence of Fourier series, Fourier cosine and sine series.
  Sections 14.1 - 14.4 of the text.

- Fourier integrals, Fourier cosine and sine integrals, Properties and applications of Fourier transforms. Fourier cosine and sine transforms
  Sections 15.1 - 15.5 of the text.

Text : Peter V. O' Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

References


1. Thomas and Finney, Calculus and Analytic Geometry, Ninth Edition, Addison–Wesley.
2. Michael D. Greenberg, Advanced Engineering Mathematics, Pearson Education, 2002.
3. James Stewart, Essential Calculus, Thompson Publications, 2007.
4. David C. Lay, Linear Algebra, Thompson Publications, 2007.
5. George F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, 2003
6. T. Gamelin, Complex Analysis, Springer-verlag, 2006
7. Brown and Churchil, Complex Variables and Applications, McGraw-Hill Higher Education; 8 edition, 2008
8. S L Loney, The elements of coordinate geometry
9. SAGE Math official website http://www.sagemath.org/
10. Gnuplot official website containing documentation and lot of examples http://www.gnuplot.info/
11. More help and examples on gnuplot http://people.duke.edu/ hpgavin/gnuplot.html
12. Maxima documentations http://maxima.sourceforge.net/documentation.html

# Mar Ivanios College, Thiruvananthapuram
# Syllabus for the Complementary Course in Mathematics
# for First Degree Programme in Chemistry

## Mathematics-I
## (Differentiation and Analytic Geometry)
## Code: AUMM 131.2b

Instructional hours per week: 4 No. of Credits:3

Overview

The complementary course intended for Chemistry students lays emphasis on the application of mathematical methods to Chemistry. The two modules on Calculus links the topic to the real world and the student's own experience as the authors of the text put it. Doing as many of exercises from the text should prove valuable in understanding the applications of the theory. Analytic geometry presented here is important in applications of calculus.

Module 1: Differentiation with applications to Chemistry

- Functions and Graphs :
  Functions and graphs of functions with examples from Chemistry. Properties of functions. New functions from old. Lines. Parametric equations and cycloids. (Some of the ideas may be familiar to the students. They should be reviewed. New ideas such as symmetry, stretching and compression, translation, parametric equations etc. should be emphasized.)
  Sections 1.1,1.2,1.3,1.5 and 1.8 of the text.
- Limit and Continuity :
  Limits. Computing Limits. Infinite limits and vertical asymptotes. Limits at infinity and horizontal asymptotes. Continuity. Limit and Continuity of Trigonometric functions.
  Sections 2.1,2.2,2.3,2.5, and 2.6 of the text.
- Derivative :
  Slope and rates of change. Derivative. Techniques of differentiation. Derivatives of Trigonometric functions. Implicit differentiation. Related rates. Local linear approximation. Differentials.
  Sections 3.1,3.2,3.3,3.4,3.5, and 3.6 of the text.
- Applications of derivative :
  Increasing and decreasing functions. Concavity. Relative Extrema, First and second derivative tests. Rectilinear motion. Absolute maxima and minima. Applied maximum anmd minimimum problems. Statement of Rolle's Theorem and Mean Value Theorem. The velocity interpretation of Mean Value Theorem. Statement of theorems 4.1.2 and 4.8.3 (consequences of the Mean Value Theorem).
  Sections 4.1,4.2,4.4,4.5,4.6 and 4.8 of the text.
- Inverse Functions :
  Inverse functions. Continuity and differentiability of inverse functions. Exponential and

logarithmic functions. Derivatives of logarithmic functions and logarithmic differentiation. Derivatives of the exponential function. Inverse trigonometric functions. Derivatives of Inverse trigonometric functions.
Sections 7.1 and relevent topics from sections 7.3 and 7.6 of the text.

- Hyperbolic Functions
  Definitions of hyperbolic functions. Graphs of hyperbolic functions. Hanging cables and other applications. Hyperbolic identities. Why they are called hyperbolic functions. Derivatives of hyperbolic functions. Inverse hyperbolic functions. Logarithmic forms of inverse hyperbolic functions. Derivatives of inverse hyperbolic functions.
  Section 7.8 of the text excluding integration part.

Module 2: Functions of Several Variables

- Functions of two or more variables. Graphs of functions of two variables. Equations of surfaces such as sphere, cylinder, cone, paraboloid, ellipsoid, hyperboloid etc. Limit and Continuity. Partial derivatives. The chain rule (various forms). Euler's theorem for homogeneous functions. Maxima and minima of functions of two variables. Use of partial derivatives in locating local maxima and minima. Lagrange method for finding maximum/minimum values of functions subject to one constraint.
  Sections 14.2,14.3,14.5,14.8 and 14.9 of the text. Also relevent topics from 14.1 and 12.7
  Exercise set 14.4; Questions 49 and 50.

Module 3: Analytic Geometry

- Conic Sections :
  Definitions of the conic sections. Equations of the conics in standard positions. Equations of the conics which are translated from standard positions vertically or horizontally. Asymptotes of a hyperbola. Reflection properties of conic sections.
- Second Degree equations in $x$ and $y$. Rotation of axes. Eliminating $xy$ - term. The Discriminant.
- Polar coordinates. Relationship between polar and rectangular coordinates.
- Conic sections in polar coordinates. Focus - Directrix Property of Conics. Eccentricity of an ellipse as a measure of flatness. Polar equations of conics. Sketching conics in polar coordinates. Kepler's Laws.
  Sections 11.4,11.5,11.1 and 11.6 of the text.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

## Semester II

## Mathematics-II
## (Integration, Power Series and Linear Algebra)

Code: AUMM 231.2b

Instructional hours per week: 4 No. of Credits: 3

Overview

The complementary course in the second semester continues the trend indicated in the first, namely, laying emphasis on applications of integral calculus and linear algebra to problems in Chemistry. Module 1 consists of various applications of integration techniques. It also covers multiple integrals. Modules 2 deals with infinite series which play a fundamental role in both mathematics and science. The third module covers matrix theory.

Module 1: Applications of integration

- Review of Indefinite Integral,Integration by substituition,Definite Integral,Fundamental Theorem of Calculus and Evaluating definite integrals by substitution.
  Sections 5.2, 5.3, 5.5, 5.6, and 5.8 of the text.
- Rectilinear motion: finding position and velocity by integration. Uniformly accelerated motion. The free-fall model. Integrating rates of change. Displacement in rectilinear motion. Distance travelled in rectilinear motion. Analysing the velocity versus time curve. Average value of a continuous function. Average velocity revisited.
  Section 5.7 of the text.
- Use of definite integrals in finding area under curves, area between two curves, volume of revolution, arc length and surface area of a solid of revolution.
  Sections 6.1, 6.2, 6.4, and 6.5 of the text.
- The idea of approximating the volume under a bounded surface in 3-space by volumes of boxes, leading to the definition of double integrals of functions of two variables over bounded regions. Evaluation of double integrals by iterated integrals. Evaluation by changing to polar co-ordinates and by suitably changing order of integration in the iterated integral. Applications to finding the volume of solids under bounded surfaces.
  Sections 15.1, 15.2, and 15.3 of the text.
- Triple integrals over bounded regions in three space. Evaluation by iterated integrals. Cylindrical coordinates and spherical coordinates and their relation to Cartesian coordinates. Use of cylindrical and spherical co-ordinates in evaluating triple integrals. Applications of triple integrals to finding volumes of solid objects.
  Sections 15.5, 12.8 and 15.7 of the text.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Module 2: Power Series

- Maclaurin and Taylor Polynomial Approximations :
  Local quadratic approximations, Maclaurin polynomials and Taylor polynomials. The Reminder Estimation Theorem
  Section 10.1 of the text.

- Review of basic ideas of Sequences, Limit of a sequence, Series, Convergent and Divergent series, Absolute convergence and Ratio Test.
  Relevent topics from sections 10.2, 10.4, and 10.6 of the text.

- Power series and their convergence :
  Results about the region of convergence of a power series(without proof). Radius of convergence. Functions defined by a power series. Results about term by term differentiation and integration of power series (without proof). Taylor's theorem with derivative form of remainder (without proof) and its use in approximating functions by polynomials. Taylor series and Maclaurin series and representation of functions by Taylor series. Taylor series of basic functions and the regions where these series converge to the respective functions. Binomial series as a Taylor series and its convergence. Obtaining Taylor series representation of other functions by differentiaion, integration, substitution etc.
  Section 10.8 and 10.9 of the text.

Text : Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

Module 3: Linear Algebra

- A quick review of Matrices and Determinants.

- Elementary Row Operations and Elementary Matrices. Invariance of rank under elementary row operations. The Row Echelon Form of a Matrix. Proofs of theorems may be omitted.
  Section 7.2 and 7.3 of the text.

- The Vector Space $\mathbb{R}^n$ :
  $n$-vector, algebra of $\mathbb{R}^n$, subspace of $\mathbb{R}^n$, linear combination, spanning set, linear dependence and independence, basis and dimension. Only basic definitions, results and simple problems need be done.
  Relevent topics from sections 6.4 and 6.5 of the text.

- The rows and columns of a matrix as elements of $\mathbb{R}^n$ for suitable n. Rank of a matrix as the maximum number of linearly independent rows/columns. Finding the rank of a matrix by reducing to echelon form.
  Section 7.4 of the text.

- Homogeneous and non-homogeneous system of linear equations. Results about the existence and nature of solution of a system of equations in terms of the ranks of the matrices involved.
  Section 7.5 and 7.7 of the text.

- The eigen values and eigen vectors. Method of finding the eigen values and eigen vectors of a matrix.
  Section 9.1 (excluding 9.1.1) of the text

- Diagonalisable matrices. Advantages of diagonalisable matrices in computing matrix powers and solving system of equations. The result(without proof) that a square matrix of order n is diagonalisabe (i) if and only if it has n linearly independent eigen vectors (ii) if it has n distinct eigen values. Method of diagonalising a matrix. Orthogonal andsymmetric matrices.
  Section 9.2 and 9.3 of the text.

Text : Peter V. O' Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

**Semester III**

**Mathematics-III**
**(Vectors and Differential Equations)**

Code: AUMM 331.2b

Instructional hours per week:5 No. of Credits: 4

Texts

1. Howard Anton, et al, *Calculus*, Seventh Edition, John Wiley

2. Peter V. O' Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007

3. K. A. Stroud, J. A. Booth, *Advanced Engineering Mathematics*, $4^{th}$ Edition, palgrave macmillan 2003.

Reference : George B. Thomas,Jr, *Thomas'Calculus*, (Eleventh Edition), Pearson,2008.

Module 1: Vector Valued Functions

- Introduction to vector-valued functions: Parametric curves in 3 space, Vector valued functions, graphs of vector valued functions
- Calculus of vector valued functions: Limits and Continuity, Derivatives and their rules, Tangent lines to graphs of vector valued functions, Derivatives of dot and cross product, Integrals of vector valued functions and their rules
- Change of Parameter; Arc length: Arc length from a vector view point and arc length as a parameter, Change of parameter, Arc length parametrizations and Properties
- Unit tangent, Normal and Binormal vectors: Unit tangent vectors, unit normal vectors, Inward unit normal vectors in 2-space, Computing T and N for curves parametrized by arc length, Binormal vectors in 3-space
- Curvature: Definition of curvature, Formulas for curvature, Radius of curvature
- Motion along a curve: Velocity, acceleration and speed, Displacement and distance travelled, Normal and tangential components of acceleration
- Directional derivatives and gradients: Directional derivatives, The Gradient, Properties of the gradient, An application of gradients
(Sections 13.1 to 13.6 and 14.6 of Text 1 )

Reference : Sections 13.1, 13.3, 13.4, 13.5, 14.5 of Reference Text

Module 2: Topics in Vector Calculus

- Vector fields: Vector fields, graphical representation of vector fields, Inverse square fields, Gradient fields, Conservative fields and potential functions, Divergence and curl, the del operator, the Laplacian operator.

- Line integrals: Line integrals and their evaluation, Line integrals in 3 space, Mass of a wire as a line integral, Arc length as a line integral, Line integrals with respect to x,y,z, Line integrals along piecewise smooth curves, Change of parameter in line integrals, reversing the direction of integration, Work as line integral, A method for calculating work.

- Independence of path, Conservative vector fields: Work integrals, independence of path, Fundamental theorem of work integrals(Statement and problems), work integral along closed path, A test for conservative vector fields, conservative vector fields in 3 space,

- Green's theorem: Greens theorem (Statement and problems), A notation for line integrals along simple closed curves, Finding area using Green's theorem.

- Surface integrals: Definition of a surface integral, Evaluating Surface integrals, Mass of a curved lamina, surface area as surface integrals.

- Application of Surface integrals, flux: Flow fields, Oriented surfaces, Evaluating flux integrals, Orientation of non parametric surfaces.

- The Divergence theorem: The Divergence theorem (Statement and problems), Using the divergence theorem to find flux, Gauss law for inverse square fields.

- Stoke's theorem: Stoke's theorem (Statement and problems), Using Stoke's theorem to calculate work, Relationship between Green's theorem and Stoke's theorem.
  (Sections 16.1 to 16.8 of Text 1)
  Reference: Sections 16.1 to 16.8 of Reference Text.
  Programmes 17 and 18 of Text 3.

Module 3: Differential equations

- First Order Differential Equations :
  Basic concepts about differential equations and their solutions. Method of solving special types of first order ODEs such as variable separable, linear, exact, homogeneous, Bournoulli, and Reccati equations. Finding the family of curves orthogonal to a given family.
  Sections 1.1, 1.2, 1.3, 1.4, 1.6, and 1.7.3 of the text 2.

- Second order differential equations :
  Preliminary Concepts. Theory of the general solution of homogeneous and non-homogeneous linear ODEs. Proofs of theorems may be omitted. However the ideas contained in the theorems must be be explained with examples.
  Sections 2.1 and 2.2 ofthe text 2

- Second order linear homogeneous ODEs with constant coefficients. The characteristic equation and its use in finding the general solution. Euler's equation.
  Section 2.4 and 2.5 of the text 2.

- Second order linear non-homogeneous ODEs. General solution as the sum of general solution of the corresponding homogeneous equation and particular integralof the given equation. The method of variation of parameters. The method of undetermined coeffients. The principle of superposition.
  Section 2.6 (only 2.6.1,2.6.2 and 2.6.3) of the text 2.

- Power series solution of Initial Value Problems (only first order equations)
  Section 4.1 of the text 2.

**Semester IV**

**Mathematics-IV**
**(Theory of Equations, Abstsract Algebra and Linear Transformations)**

Code: AUMM 431.2b

Instructional hours per week: 5 No. of Credits: 4

Module 1: Theory of Equations

- Fundamental theorem of Algebra (without proof), relations between roots and coefficients of a polynomial equation, Transformation of polynomial equations and special cases.
- Cubic equations and Biquadratic equations, simple problems, finding nature of roots of polynomials without solving-Des Cartes' rule of signs,
- Remarks about necessity of numerical methods for solving polynomials of degree five and above, finding approximate roots via bisection method, by iteration, Newton-Raphson method, Modified Newton-Raphson method.
(Chapter VI of Text 1; Programme 1 of Text 2.)

Texts : 1. Barnard and Child, *Higher Algebra*, Macmillan
2. K A Stroud, *Advanced Engineering Mathematics*, $4^{th}$ edition,Palgrave, 2003

Module 2: Abstract Algebra

- Binary Operations, Groups–definition and examples, elementary properties, finite groups and subgroups, cyclic groups, elementary properties, groups of permutations - Illustrations of $S_3(D-3)$ and $D_4$
- Rings and Fields - definition and examples

[Sections 2, 4, 5, 6, 8 (excluding the subsection on Cayley's theorem) and 18 (excluding the subsection on homomorphism and isomorphism) of text book . Proofs of theorems are excluded. However ideas contained in theorems and definitions should be explained with illustrative examples and problems.]

Text : J B Fraleigh, *A First Course in Abstract Algebra*, Narosa Publications

( See also J A Gallian, *Contemporary Abstract Algebra*, Narosa Publications for examples of symmetry groups) ]

Module 3: Linear Transformations

- Vector equations. Vectors in $\mathbb{R}^2$, $\mathbb{R}^3$ and $\mathbb{R}^n$. Linear combinations
- Linear independence of vectors. Linear independence of Matrix columns. Linear independence of sets of one or two vectors, sets of two or more vectors, characterization of linearly dependent sets.

- Linear transformations from $\mathbb{R}^n$ into $\mathbb{R}^m$. Matrix transformations. Linear transformation.
- The matrix of a Linear transformation. Matrix representation of simple tranformations such as rotation, reflection, projection etc. on the plane.

[Sections 1.3, 1.7, 1.8, and 1.9 of text]

Text : David C. Lay, *Linear Algebra and its applications*, Third Edition Pearson

References


1. Thomas and Finney, Calculus and Analytic Geometry, Ninth Edition, Addison–Wesley.
2. Michael D. Greenberg, Advanced Engineering Mathematics, Pearson Education, 2002.
3. James Stewart, Essential Calculus, Thompson Publications, 2007.
4. David C. Lay, Linear Algebra, Thompson Publications, 2007.
5. George F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, 2003
6. T. Gamelin, Complex Analysis, Springer-verlag, 2006
7. Brown and Churchil, Complex Variables and Applications, McGraw-Hill Higher Education; 8 edition, 2008
8. S L Loney, The elements of coordinate geometry
9. SAGE Math official website http://www.sagemath.org/
10. Gnuplot official website containing documentation and lot of examples http://www.gnuplot.info/
11. More help and examples on gnuplot http://people.duke.edu/ hpgavin/gnuplot.html
12. Maxima documentations http://maxima.sourceforge.net/documentation.html

# Mar Ivanios College, Thiruvananthapuram
# Syllabus for the Complementary Course in Mathematics
# for First Degree Programme in Economics

Semester I

Mathematics for Economics-I

CODE: AUMM 131.1$a$ — Instructional hours per week: 3

No. of Credits: 2

Overview of the course:

The complementary course intended for Economics students lays emphsis on the increased use of mathematical methods in Economics. The first Module of the first semester course discusses the basic concepts of functions, limits and continuity, which is essential to understand what is to follow in subsequent Modules. The second Module gives a brief introduction of Mathematical Economics, which familiarises the functions and curves commonly used in Economics. The third Module is on Differentiation. The concept of differentiation should be made clear; however, the applications of differentiation in economics are not discussed in this module.

Module 1: Functions, Limits and Continuity

- Functions: Definition and examples of functions, domain and range of a function, graph of a function, notion of implicit and explicit functions, curves of functions, solution of equations in one variable, solution of simultaneous equations in two variables.

- Limits and continuity of functions: Notion of the limit of a function with sufficient examples, algebra of limits (No proof), theorems on limits :$\lim_{x\to a} \frac{x^n - a^n}{x - a} = nx^{n-1}$, $\lim_{x\to 0} \frac{\sin x}{x} = 1$,$\lim_{x\to 0} \frac{e^x - 1}{x} = 1$, $\lim_{x\to 0} \frac{a^x - 1}{x} = \log a$, for $a > 0$(No proof), definition and examples of continuous functions, discontinuity, examples, geometrical meaning of continuity.
  Chapter 2: sec. 1-5, 8-9; Chapter 4: sec. 1-7; Chapter 9: sec. 1-3

Module 2: Functions in Economic Theory

- The nature of mathematical economics, Economic functions: Demand functions and curves, total revenue functions and curves, Cost functions and curves.
  Chapter 5: 1-5

Module 3:Differentiation-I

- Differentiation: Differentiation of functions of one variable, derivative as a rate measure,rules of differentiation, derivative of a function at a point, product rule, quotient rule,function of a function rule, derivatives of standard functions (results only), differentiation of implicit functions, derivativesof exponential and logarithmic functions, geometrical interpretation of the derivative, second and higher order derivatives.
  Chapter 6: Sec.1-3,6; Chapter 7: Sec.1-7;Chapter 10: Sec.1-2

Text : R G D Allen, *Mathematical Analysis for Economics*, AITBS Publishers, D-2/15. Krishnan Nagar, New Delhi

References:

1. Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.

2. Chiang A.C. and K. Wainwright, *Fundamental Methods of Mathematical Economics*, 4thEdition, McGraw-Hill, New York, 2005.(cw)

3. Dowling E.T, *Introduction to Mathematical Economics*, 2nd Edition, Schaum's Series,McGraw-Hill, New York, 2003(ETD)

4. Mary George, Thomaskutty, *A Text Book of Mathematical Economics*,Discovery Publishers, New Delhi.

Distribution of instructional hours:

Module 1: 17 hours; Module 2: 10 hours; Module 3: 27 hours

Semester II

Mathematics for Economics-II

CODE: AUMM 231.1a

Instructional hours per week: 3

No. of Credits: 3

Overview of the course:

The first module discusses applications of derivatives. While discourses the concepts of increasing and decreasing functionsor maxima and minima, illustration through functions familiar in Economics may be of great advantage .Effort should be taken to elicit various applications of differentiation in Economics. The second module is on partialdifferentiation. Functions on several variables should be made clear before starting partial differentiation. This module unveils many appealing applications of Mathematics in Economics. The third module deals with the scope and utility of linear programming. Only graphical method of solution is discussed.

Module 1: Differentiation-II

- Applications of derivatives: the sign and magnitude of the derivative, differentials and approximations, increasing and decreasing functions, slope of a curve, tangents to curves, turning points, points of inflexion,convexity of curves, maxima and minima of functions of one variable
- Applications of derivatives in Economics: the problem ofaverage and marginal values(such asmarginal revenue, marginal cost), Application of differentiation in finding marginal concepts and Elasticity, Relation between AC and MC, Relation between AR and MR, problems of monopoly and duopoly in economic theory, elasticity of a function, elasticity of demand.
  Text-1: Chapter 6: Sec. 4,5,8; Chapter 8: Sec. 1-8 ; Chapter 10: sec. 4-6

Module 2: Partial Differentiation

- Partial Differentiation: Functions of several variables, Definition and examples partialdifferentiation of functions of two variables, geometrical interpretation of partial derivatives, total differentials,chain rule for derivatives of implicit functions, higher order partial derivatives, Young's theorem, homogeneous functions, Euler's theorem, maxima and minima of functions of manyvariables.
- Applications of partial derivatives in Economics:inferior and normal goods, competitive and complementary goods, partial elasticity, maxima and minima problems in economics, the linear homogeneous production function.
  Text-2: Chapter 4: Sec.1-11, Chapter 5: Sec.4

Module 32: Linear Programming

- Applications and model formulation: Meaning of Linear programming,Solution of an LPP: feasible and optimal, Graphic Solution of an LPP (Extreme Point method only).
  Text-3: Chapter3: Sec. 1-3

Texts

1. R G D Allen, *Mathematical Analysis for Economics*, AITBS Publishers, D-2/15. Krishnan Nagar, New Delhi

2. Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.

3. J. K. Sarma, *Operations Research-Theory and Applications*, $3^{rd}$,MacMillan India Ltd, Delhi.


References:


1. Chiang A.C. and K. Wainwright, *Fundamental Methods of Mathematical Economics*, 4thEdition, McGraw-Hill, New York, 2005.(cw)

2. Dowling E.T, *Introduction to Mathematical Economics*, 2nd Edition, Schaum's Series,McGraw-Hill, New York, 2003(ETD)

3. Mary George, Thomaskutty, *A Text Book of Mathematical Economics*,Discovery Publishers, New Delhi.


Distribution of instructional hours:

Module 1: 17 hours; Module 2: 27 hours; Module 3: 10 hours

Semester III
Mathematics for Economics-III

CODE: AUMM 331.1$a$ — Instructional hours per week: 3
No. of Credits: 3

Overview of the course:
The course follows the trends set in the first two semesters. Integration techniques, definiteintegrals and approximate integration are discussed in the first module. Some immediate applications of integration in economics such as finding total from marginal are also considered. Various infinite series namely, Geometric series, Taylor series and Exponential series form the content of the second module.A brief study on Matrix Algebra is done in the third module.

Module 1: Integration

- Integration: definition of definite integral, definite integrals as areas, indefinite integrals and inverse differentiation, the techniques of integration (integration by substitution, integration by parts), definite integrals and approximate integration (Simpson's rule and trapezoidal rule).
- Applications in Economics: the relation between average and marginal concepts.
  Text 1: Chapter 15.1-15.6

Module 2: Series

- Series: Geometric series, Taylor's formula, Taylor series, Exponential series.
  Text2: Chapter 7: Sec.1-5

Module 3: Matrix Algebra

- Matrix Operations: Addition, subtraction and scalar multiplication, multiplication of matrices; Commutative, Associative and Distributive laws, identity matrices and null matrices, transposes, determinants and non-singularity of matrix using determinants, Cramer's Rule.
  Text3: Chapter 4: Sec.2,4,5 relevent topics from sec. 6; Chapter5: Sec.2,3,5(only relevent topics)

Texts

1. R G D Allen, *Mathematical Analysis for Economics*, AITBS Publishers, D-2/15. Krishnan Nagar, New Delhi
2. Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.
3. Chiang A.C. and K. Wainwrighta, *Fundamental Methods of Mathematical Economics*, $4^{th}$ Edition, McGraw-Hill, New York, 2005.(cw) ,MacMillan India Ltd, Delhi.

REFERENCES:

1. Dowling E.T, *Introduction to Mathematical Economics*, 2nd Edition, Schaum's Series,McGraw-Hill, New York, 2003(ETD)

2. Mary George, Thomaskutty, *A Text Book of Mathematical Economics*,Discovery Publishers, New Delhi.

Distribution of instructional hours:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours

Semester IV

Mathematics for Economics-IV

CODE: AUMM 431.1$a$ — Instructional hours per week: 3

No. of Credits: 3

Overview of the course

The first two modules in this course treat differential equations, the solutions of which areimportant in most mathematical models. First order differential equations are consideredin the first module, whereas second order differential equations with constant coefficients, together with the Euler equation are dealt with in the second module. The second module also highlights some applications of integration to Economics. The third module deals with difference equations.

Module 1: Differential Equations-I

- Differential Equations: order and degree of a differential equation, Formulation of differential equations, geometrical interpretationof a differential equation representing a family of curves
- Solution of differential equations: Variables separable, Homogeneous equations,Exact equations, Linear equations
  Text 2: Chapter 8: Sec.1-7

Module 2: Differential Equations-II

- Differential equations of higher order: Second order differential equations with constant-coefficients with RHS as one of $x^n$, $e^{ax}$
- Applications in Economics: Domar's capital expansion model.
  Text 2: Chapter 8: Sec. 8-9

Module 3: Difference Equations

- Finite differences, operators(△, E and D); difference equations, solutions, homogeneous linear difference equations with constant coefficients.
  Text 2: Chapter 9: Sec. 1-5

Text :

Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.

REFERENCES:


1. R G D Allen, *Mathematical Analysis for Economics*, AITBS Publishers, D-2/15. Krishnan Nagar, New Delhi
2. Taro Yamane, *Mathematics for Economists, An Elementary Survey*, PHI, New Delhi.
3. Chiang A.C. and K. Wainwright, *Fundamental Methods of Mathematical Economics*, 4thEdition, McGraw-Hill, New York, 2005.(cw)
4. Dowling E.T, *Introduction to Mathematical Economics*, 2nd Edition, Schaum's Series,McGraw-Hill, New York, 2003(ETD)

5. Mary George, Thomaskutty, *A Text Book of Mathematical Economics*,Discovery Publishers, New Delhi.

Distribution of instructional hours:

Module 1: 18 hours; Module 2: 18 hours; Module 3: 18 hours