SCHOOL OF MATHEMATICAL SCIENCES

INTRODUCTION

The School of Mathematical Sciences was established on May 29, 1974. As with the other Science Schools, the School offers the Bachelor of Science and Bachelor of Applied Science degrees. In addition, the School is also involved in the Bachelor of Science with Education and Bachelor of Education degrees.
The Bachelor of Science (Mathematics) program was formulated in an effort to produce graduates who are well-trained in the Mathematical Sciences to meet the nation's manpower needs. The curriculum was devised so as to provide a broad-based and rigorous mathematics education. The skills obtained at the end of the program will provide a firm foundation to enable the graduate to further advance their knowledge in the Mathematical Sciences.

VISION

To be a recognized department of mathematics that can attract excellent students and produce quality mathematicians nationally and internationally.

MISSION

To lead and innovate in achieving excellence in Mathematical Sciences at the international level through advancing and disseminating knowledge and truth; instilling qualities that stress academic excellence and professionalism; developing holistic individuals; and providing a strong commitment towards the society aspiration; the country's vision and universal aspirations.

PROGRAM LEARNING OUTCOMES

At the end of the program, the students will possess:

1. Knowledge
    i) Fundamental and broad mathematical principles
    ii) Analytical and computational techniques
    iii) Integration of mathematical knowledge in solving problem
2. Practical skills
    i) Relevant computing technologies and software for problem solving
    ii) Technological literacy and skills
3. Social skills and responsibilities
    i) Actively participate in outreach activities at national and international level
    ii) Understand and appreciate culture and cultural diversity
    iii) Seek objectivity and shun bias
4. Ethics, professionalism and humanities
    i) Carry out their responsibilities with professional values and ethics
    ii) Value ethical attitudes and behaviour
5. Communication, leadership and team skills
    i) Communicate effectively and efficiently in both oral and written form
    ii) Reading and listening
    iii) Function effectively as an individual and as team members to achieve common goal
6. Scientific methods, critical thinking and problem solving skills
    i) Use logical reasoning and critical thinking to make informed decisions
7. Lifelong learning and information management
    i) Use mathematical rigour for postgraduate studies and research
8. Entrepreneurship and managerial skills
    i) Assumed leadership roles in teams and engage constructively in various groups.

MAIN OFFICERS

DEAN

Assoc. Prof. Ahmad Izani Md. Ismail

DEPUTY DEANS

Assoc. Prof. Abd Rahni Mt Piah
(Academic and Student Development)

Assoc. Prof. Norhashidah Mohd. Ali
(Graduate Studies and Research)

PROGRAM CHAIRPERSONS

Dr. Hailiza Kamarul Haili
Science
(Mathematics)

Ms. Suraiya Kassim
Applied Science
(Mathematics and Economics)

Assoc. Prof. Adam Baharum
Applied Science
(Applied Statistics / Operations Research)

Assoc. Prof. Ahmad Abdul Majid
Applied Science
(Mathematical Modelling / Computer Modelling)

Assoc. Prof. Michael Khoo Boon Chong
Industry & Community Network

Dr. Yahya Abu Hasan
Academic Co-ordinator

ASSISTANT REGISTRARS

Mr. Abd. Manaf Muhamad Yunus
Senior Assistant Registrar

Ms. Nor Farah Shaik Omar
Assistant Registrar

LIST OF ADMINISTRATIVE AND ACADEMIC STAFF
SCHOOL OF MATHEMATICAL SCIENCES

ADMINISTRATION
DEAN
Assoc. Prof. Ahmad Izani Md. Ismail dean_mat@usm.my

DEPUTY DEAN (Academic and Student Development)
Assoc. Prof. Abd Rahni Mt Piah ddsa_mat@usm.my

DEPUTY DEAN (Graduate Studies and Research)
Assoc. Prof. Norhashidah Mohd. Ali ddpg_mat@usm.my

PROGRAM CHAIRPERSONS

SCIENCE (MATHEMATICS)
Dr. Hailiza Kamarul Haili ahyahya@cs.usm.my

APPLIED SCIENCES (MATHEMATICS AND ECONOMICS)
Ms. Suraiya Kassim ksuraya@cs.usm.my

APPLIED SCIENCES (APPLIED STATISTICS / OPERATIONS RESEARCH)
Prof. Madya Adam Baharum nahmad@cs.usm.my

APPLIED SCIENCE (MATHEMATICAL MODELLING / COMPUTER MODELLING)
Assoc. Prof. Ahmad Abd. Majid majid@cs.usm.my

INDUSTRY & COMMUNITY NETWORK
Assoc. Prof. Michael Khoo Boon Chong mkbc@usm.my

ACADEMIC CO-ORDINATOR
Dr. Yahya Abu Hasan zarita@cs.usm.my

SENIOR ASSISTANT REGISTRAR
Mr. Abd. Manaf Muhamad Yunus abdmanaf@notes.usm.my

ASSISTANT REGISTRAR
Ms. Nor Farah Shaik Omar nor_farah@notes.usm.my

ACADEMIC STAFF

PROFESSOR	TELEPHONE EXTENSION	E-MAIL
Dato' Rosihan M. Ali, Dr	3966	rosihan@cs.usm.my

ASSOCIATE PROFESSOR		
Adam Baharum, Mr	3942	adam@cs.usm.my
Abd Rahni Mt Piah, Dr	3945	arahni@cs.usm.my
Ahmad Abd. Majid, Dr	3965	majid@cs.usm.my
Ahmad Izani Md. Ismail, Dr	3657	izani@cs.usm.my
Jamaludin Md. Ali, Dr	3656	jamaluma@cs.usm.my
Low Heng Chin, Dr	3641	hclow@cs.usm.my
Michael Khoo, Dr	3941	mkbc@usm.my
Norhashidah Hj. Mohd. Ali, Dr	3960	shidah@cs.usm.my
Sriwulan Adji, Dr	3967	wulan@cs.usm.my
Zarita Zainuddin, Dr	3940	zarita@cs.usm.my

SENIOR LECTURER		
Adli Mustafa, Dr	3968	adli@cs.usm.my
Andrew Rajah A/L Balasingam Gnanaraj, Dr	4780	andy@cs.usm.my
Ang Miin Huey, Dr	4772	mathamh@cs.usm.my
Azhana Ahmad, Dr	4771	azhana@usm.my
Che Rohani Yaacob, Ms	2065	rohani@cs.usm.my
D.S. Sankar, Dr	4777	sankar_ds@usm.my
Ena Jamal, Ms	3658	ena@cs.usm.my
Hailiza Kamarul Haili, Dr	3648	hailiza@cs.usm.my
Hajar Sulaiman, Dr	4779	hajar@cs.usm.my
Husna Hasan, Dr	3969	husna@cs.usm.my
Kong Voon Pang, Dr	3943	kongvp@cs.usm.my
Lee See Keong, Dr	2070	sklee@cs.usm.my
Mohd. Tahir Ismail, Dr	2071	mtahir@cs.usm.my
Noor Atinah Ahmad, Dr	4767	atinah@cs.usm.my
Norhashidah Awang, Dr	4774	shidah@usm.my
Norlida Mohd. Noor, Ms	3958	norlida@cs.usm.my
Ong Hong Choon, Dr	4763	hcong@cs.usm.my
Roslan Hasni @ Abdullah, Dr	2355	hroslan@cs.usm.my
Rosmanjawati Abdul Rahman, Dr	4778	rosmanjawati@usm.my
Saratha A/P Sathasivam, Dr	2428	saratha@cs.usm.my
Suraiya Kassim, Ms	4773	ksuraya@cs.usm.my
Teh Su Yean, Dr	4770	syteh@usm.my
Yahya Abu Hasan, Dr	4783	ahyahya@cs.usm.my
Zainudin Arsad, Dr	2069	zainudin@cs.usm.my
Zalila Ali, Ms	4775	zalila@cs.usm.my

LECTURER		
Noor Hayati Marzuki, Ms	2356	hayati@cs.usm.my

SUPPORT / TECHNICAL STAFF

Norrizah Hj. Abd. Hamid	Administrative Assistant (Secretarial)
Rosila Suleiman	Administrative Assistant (Secretarial)
Azizah Abdul Rani	Administrative Assistant (Clerical/Operation-Finance)
Faridah Hashim	Administrative Assistant (Clerical/Operation)
Khairul Azly Abdul Kadir	Administrative Assistant (Clerical/Operation)
Yusnita Yusop	Administrative Assistant (Clerical/Operation)
Zalem Tekor	Administrative Assistant (Clerical/Operation)
Syed Mohamed Hussain Syed Osman	Technician
Hartini Ahmad	Technician
Rohartina Razali	Administrative Junior Assistant (Typist)
Suriati Mukhtar	Administrative Junior Assistant (Typist)
Arzahar Ismail	Office Assistant
Mohd Ibrahim Mohd Shariff	Office Assistant

PROGRAM REQUIREMENT

Type of Courses	Classification	Unit
Core	T	65
Minor / Elective	M / E	20*
University	U	15-18
	Total Number of Units	100-103

* A student who chooses a Minor needs to accumulate 16 units from one of the Minor programs and obtain units from MAT181/4 : Programming for Scientific Applications as an Elective.

CORE COURSES

A student has to accumulate **65 units** as follows:

Compulsory (45 units)

MAT 101/4	:	Calculus
MAT 111/4	:	Linear Algebra
MAT 161/4	:	Elementary Statistics
MAT 102/4	:	Advanced Calculus
MAT 122/4	:	Differential Equations I
MAT 202/4	:	Introduction to Analysis
MAT 263/4	:	Probability Theory
MAT 282/4	:	Engineering Computation I
MSS 211/4	:	Modern Algebra
MSS 212/4	:	Further Linear Algebra
MSS 281/2	:	Mathematical Software Laboratory I
MSS 282/3	:	Mathematical Software Laboratory II

Choose 16 units from:

MAT 222/4	:	Differential Equations II
MAT 251/4	:	Introduction to Operations Research
MSG 228/4	:	Introduction to Modelling
MSG 252/4	:	Linear and Integer Programming
MAT 363/4	:	Statistical Inference
MSG 322/4	:	Fluid Mechanics
MSG 356/4	:	Mathematical Programming
MSG 389/4	:	Engineering Computation II
MSS 301/4	:	Complex Analysis
MSS 302/4	:	Real Analysis
MSS 317/4	:	Coding Theory
MSS 318/4	:	Discrete Mathematics
MSS 392/4	:	Minor Project

Choose 4 units from:

BOM 111/4	:	Biodiversity
BOM 112/4	:	Ecology
CPT 112/4	:	Discrete Structures
CPT 114/4	:	Logic & Applications
ZCA 101/4	:	Physics I (Mechanics)
ZCA 102/4	:	Physics II (Electricity and Magnetism)

SKILL / OPTIONAL COURSES

In order to fulfill this requirement, students of the School of Mathematical Sciences are allowed to take any course outside the Schools of Mathematical Sciences, Chemical Sciences, Biological Sciences and Physics. Students are encouraged to take English language [LHP code], foreign languages, thinking techniques, history and philosophy of science courses.

COURSE PRE-REQUISITE AND SEMESTER OF OFFERING

The prerequisites and semester of offering of the core courses and MAT 181/4 are as follows:

	Code & Title of Courses			Prerequisite	Semester Offered
1.	MAT 101/4	:	Calculus	-	1
2.	MAT 111/4	:	Linear Algebra	-	1, 2
3.	MAT 161/4	:	Elementary Statistics	-	1, 2
4.	MAT 102/4	:	Advanced Calculus	MAT 101 (S)	2
5.	MAT 122/4	:	Differential Equations I	MAT 101 (S) and MAT 111 (S)	2
6.	MAT 181/4	:	Programming for Scientific Applications	-	1, 2

7.	MAT 202/4	:	Introductions to Analysis	MAT 102 (S)	2
8.	MAT 222/4	:	Differential Equations II	MAT 122 (S)	1
9.	MAT 251/4	:	Introduction to Operations Research	MAT 161 (S) and MAT 111 (S)	1
10.	MAT 263/4	:	Probability Theory	MAT 161 (S) and MAT 102 (S)	1, 2
11.	MAT 282/4	:	Engineering Computation I	MAT 181 (S)	1
12.	MSS 211/4	:	Modern Algebra	MAT 111 (S)	2
13.	MSS 212/4	:	Further Linear Algebra	MAT 111 (S)	2
14.	MSS 281/2	:	Mathematical Software Laboratory I	MAT 181 (S)	1
15.	MSS 282/3	:	Mathematical Software Laboratory II	MSS 281 (S)	2
16.	MAT 363/4	:	Statistical Inference	MAT 263 (S)	1
17.	MSG 228/4	:	Introduction to Modelling	MAT 122 (S)	2
18.	MSG 252/4	:	Linear and Integer Programming	MAT 251 (S)	2
19.	MSG 322/4	:	Fluid Mechanics	MAT 222 (S)	2
20.	MSG 356/4	:	Mathematical Programming	MAT 251 (S)	2
21.	MSG 389/4	:	Engineering Computation II	MAT 282 (S)	2
22.	MSS 301/4	:	Complex Analysis	MAT 102 (S)	2
23.	MSS 302/4	:	Real Analysis	MAT 202 (S)	1
24.	MSS 317/4	:	Coding Theory	MSS 211(S)	1
25.	MSS 318/4	:	Discrete Mathematics	MAT 111(S)	2
26.	MSS 392/4	:	Minor Project	MAT 202 (S) and MSS 211 (S)	2
27.	BOM 111/4	:	Biodiversity	-	1
28.	BOM 112/4	:	Basic Ecology	-	1
29.	CPT 112/4	:	Discrete Structures	-	1
30.	CPT 114/4	:	Logic & Applications	-	2
31.	ZCA 101/4	:	Physics I (Mechanics)	-	1, 2
32.	ZCA 102/4	:	Physics II (Electricity and Magnetism)	-	1, 2

Sequential prerequisite (S) means if course A is a sequential prerequisite (S) to course B, then course A must be taken and assessed before course B is taken.

SPECIALISATION AND COMPULSORY CORE COURSES REGISTRATION GUIDE

Year of Study	Semester 1		Units	Semester 2		Units
1	MAT 101 MAT 111 MAT 181		4 4 4	MAT 102 MAT 122 MSS 212		4 4 4
2	MAT 161 MAT 282 MSS 281		4 4 2	MAT 202 MAT 263 MSS 211 MSS 282		4 4 4 3
3	Applied Mathematics	MAT 222*	4	Applied Mathematics	MSG 228* MSG 322* MSG 389*	4 4 4
	Pure Mathematics	MSS 302* MSS 317*	4 4	Pure Mathematics	MSS 301* MSS 318* MSS 392*	4 4 4
	Statistics & Operations Research	MAT 251* MAT 363*	4 4	Statistics & Operations Research	MSG 252* MSG 356*	4 4

* *Elective Courses: Choose 4 of the 13 listed courses (preferably in a specific area of mathematics)*

MATHEMATICS MINOR PROGRAM

1. MAA 101/4 : Calculus for Science Students I
2. MAA 102/4 : Calculus for Science Students II
3. MAA 111/4 : Algebra for Science Students
4. MAA 161/4 : Statistics for Science Students
5. MAT 122/4 : Differential Equations I
6. MSG 162/4 : Applied Statistical Methods
7. MAT 203/4 : Vector Calculus
8. MAT 263/4 : Probability Theory
9. MSG 262/4 : Quality Control
10. MSS 211/4 : Modern Algebra

Mathematics minor students have to accumulate 16 units and it is compulsory for them to take both MAA 101/4 and MAA 111/4 either as core or minor courses. Courses which they have taken to fulfill the core requirements must be replaced by the above listed courses. Please refer to the minor program guide book for further details.

SCHOOL’S FACILITIES

The School of Mathematical Sciences has 3 undergraduate computer laboratories, a postgraduate computer laboratory and a research and development laboratory. These laboratories are equipped with MS Windows based computer facilities, net-worked laser printers and CD Writers. Besides that, the School has also a TI-92 hand-held computer facilities and a graphic calculator laboratory.

GENERAL INFORMATION

Awards

Besides awards from the University, there are 3 other specific awards for mathematics students:

1. Tan Sri Dato' Professor Sir Alexander Oppenheim Book Prize for the best first year student.
2. Dato’ Abdul Razak Yusof Gold Medal Award to the best final year student in the field of Mathematical Sciences.
3. Telesol Sdn. Bhd. Gold Medal Award to the best final year student in the field of Applied Sciences (Mathematics).

The Dean Lists certificates are awarded every semester to excellent students who have obtained a GPA of at least 3.5 and accumulated at least 14 units.

The Dean’s Award will be conferred to a student who has excelled in both the academic and co-curriculum activities. Only one award is available for each year of study from each program. A student of a CGPA of 3.7 and above in an academic session is qualified to be considered for this award.

Mathematical Sciences Society

This society organizes various activities in order to promote Mathematics amongst USM and secondary school students. Students of School of Mathematical Sciences are encouraged to join this society.

Graduate Program

The School also offers the following graduate programs:

- Master of Science (Mathematics) by research
- Master of Science (Statistics) by research
- Mixed Mode Master of Science (Mathematics)
- Mixed Mode Master of Science (Statistics)
- Master of Science (Teaching of Mathematics) by course-work
- Doctor of Philosophy by research

Industry Advisory Panels for School of Mathematical Sciences

1. Dr. Cheong Wee Tat
   WW Process Innovation
   IBM International Holdings B.V. Singapore Branch
   Kaki Bukit View, #05-20 Techview
   Singapore 415941

2. Mr. Edward Chooi Kok Kee
   Quality Management & Methods (QMM)
   Robert Bosch (Malaysia) Sdn. Bhd.
   Free Industrial Zone, Phase 1
   11900 Bayan Lepas

3. Mr. Amir Hamzah Mohd. Nawawi
   Senior Engineering Manager
   Advanced Manufacturing Technology
   Motorola Technology Sdn. Bhd.
   Plot 2, Bayan Lepas Technoplex Industrial Park
   Mukim 12 SWD
   11900 Bayan Lepas

SYNOPSIS OF COURSES

1. MAT 101/4 Calculus

Functions:
Concept of function.
$|x|$, $[x]$, rational functions, trigonometric functions.
Operations of functions (including composite functions).
Graph of functions.
Inverse functions (including inverse of trigonometric functions).
Limit:
Definition using $\varepsilon - \delta$, proof is emphasized using definition of limit.
One-sided limits, limit theorems, squeezing principle, $\lim_{x\to 0}\frac{\sin x}{x}$, properties of limits (uniqueness, preservation of order).
Continuity:
Concept of continuity, one-sided continuity, continuity on a closed interval.
Intermediate value theorem, extremum theorem, completeness axiom for R.
Derivatives:
Concept of derivative.
Differentiability and continuity, properties and rules of differentiation, chain rule.
Parametric representation for curves, implicit function and its derivatives.
Rolle's theorem, mean value theorem.
Tests for monotonicity, concavity, local extremum.
Applications - curve sketching, rates of change and modelling problems.
Antiderivatives.

Riemann integral:
Upper and lower sums, integrability, fundamental theorem of calculus, integral as a limit of Riemann sums.
Exponential and logarithmic functions.
Techniques and applications of integration:
Various techniques of integration, arc length, area, volume and surface area of revolution.

Course Outcomes

Upon completion of this course, students are able to

1. know about functions and limits, and their connection with differentiation and integration
2. find the derivative of functions using various rules of differentiation
3. evaluate integral of functions using various quadrature methods
4. prove, interpret and apply key theorems in differential and integral calculus
5. apply the methods in differential and integral calculus to problems in life and physical sciences.

Reference Books

1. Spivak, M. (1994). *Calculus*, 3rd edition. Publish or Perish, Inc.
2. Apostol, T.M. (1967). *Calculus Vol I*, 2nd edition. John Wiley & Sons.
3. Stewart, J. (2003). *Calculus*, 5th edition. Thomson Brooks/Cole.

2. MAA 101/4 Calculus for Science Students I

Functions:
Domain, co-domain, range, 1-1 function, onto function.
$|x|$, $[x]$, rational functions, transcendental functions (including hyperbolic functions).
Operations of functions (including composition of functions).
Graph of functions.
Inverse function.
Polar coordinates.
Limit:
Concept of limit and its basic properties.
Continuity:
Concept of continuous functions.
Intermediate value theorem and extremum theorem.
Differentiation:
Differentiability and continuity, rules of differentiation, chain rule.
Parametric representation for curves, implicit function and its derivative.
Rolle's theorem, mean value theorem.
Applications - tangent, normal, maximum and minimum, curve sketching, rates of change, differential, L'Hospital's rule, Newton Raphson method.
Antiderivative.
Integration:
Definite integral as a limit of Riemann sum, condition for integrability. Fundamental theorem of calculus.

Exponential function and logarithmic function.
Techniques and applications of integration:
Various techniques of integration, arc length, area, volume and surface area of revolution, centre of gravity, trapezoidal rule and applications in biology, chemistry and economics.

Course Outcomes
Upon completion of this course, students are able to
1. know about functions and limits, and their connection with differentiation and integration
2. find the derivative of functions using various rules of differentiation
3. evaluate integral of functions using various quadrature methods
4. apply the methods in differential and integral calculus to problems in life and physical sciences

Reference Books
1. Stewart, J. (2003). *Calculus*, 5th edition. Thomson Brooks/Cole.
2. Weir, M.D., Hass J. and Giordano F. R. (2005). *Thomas Calculus*, 11th edition. Pearson Addison Wesley.
3. Berresford, G.C. and Rocket, A.M. (2004). *Applied Calculus*, 3rd edition. Houghton-Mifflin.
4. Tan, S. (2005). *Applied Calculus for Managerial, Life and Social Sciences*, 6th edition. Thomson Brooks/Cole.

3. MAT 111/4 Linear Algebra

Vectors in R^n :
Vector operations, position vectors, inner product, cross product, equations of line and plane.
Matrices:
Matrix operations, row and column elementary operations, elementary matrix, system of linear equations (solutions in the form of homogeneous solution and particular solution), Gauss elimination process, inverse matrix.
Vector spaces in R^n :
Linear independence, basis, dimension, subspace, R^n as an inner product space, Cauchy Schwartz inequality, Gram-Schmidt orthogonalization process.
Linear transformation $T : R^n \rightarrow R^m$:
Matrix representation of linear transformation with respect to an ordered basis, proof of matrix properties in terms of linear transformation, row space, column space, kernel and images, applications for least squares problems.
Eigenvalues, eigenvectors, diagonalization of matrices.

Course Outcomes
Upon completion of this course, students are able to
1. use the elementary row operations to obtain solutions of systems of linear equations
2. interrelate concepts of the vector space R^n with the general vector space

3. apply concepts of inner product to find the orthonormal basis through Gram-Schmidt process and least squares solutions
4. interrelate matrices with linear transformations
5. identify the concepts of diagonalizing a matrix.

Reference Books

1. Smith, L. (1998). *Linear Algebra*, 3rd edition. Springer-Verlag.
2. Halmos, P.R. (1974). *Finite Dimensional Vector Space*, 2nd edition. Springer-Verlag.
3. Leon, S.J. (1990). *Linear Algebra with Applications*, 3rd edition. Macmillan.

4. MAA 111/4 Algebra for Science Students

Matrices:
Matrix operations, elementary row and column operations, elementary matrix, echelon form, row reduced echelon, finding inverse of a matrix.
System of linear equations :
Homogeneous system and non-homogeneous system, Gauss elimination, Gauss-Jordan elimination, solutions of linear system of equations with LU decomposition.
Determinants:
Finding a determinant through a minor expansion, properties of determinant, finding the inverse of a matrix using determinant, Cramer's rule.

Vector space in R^n :
Concept of linear independence, spanning sets and bases, dimensions.
Null space, column space and row space of a matrix.
Gram-Schmidt orthogonalization process.
Matrix diagonalization:
Eigenvalues and eigenvectors, Cayley-Hamilton theorem,
methods of matrix diagonalization.

Course Outcomes

Upon completion of this course, students are able to

1. find solutions of linear systems effectively using the theory of matrices, and develop a firm understanding of the solutions structure of linear systems
2. describe the key concepts of Euclidean vector space R^n and linear transformations on R^n
3. link between the orthogonality concept with the least square method to solve inconsistencies
4. solve many problems on matrix diagonalization.

Reference Books

1. Anton, H. (2005). *Elementary Linear Algebra*, 9th edition. John Wiley & Sons.
2. Noble, B. and Daniel, J.W. (1988). *Applied Linear Algebra*, 3rd edition. Prentice Hall.

3. Edward, C.H., Jr. and Penney, D.E. (1988). *Elementary Linear Algebra*, Prentice Hall.
4. Roman, S. (1985). *An Introduction to Linear Algebra with Applications*, Saunders College Publication.

5. MAT 161/4 Elementary Statistics

Numerical and graphical description of data.
Empirical law and Chebyshev theorem.
Introduction to probability: concept of probability, counting techniques, rules of probability, independence, conditional probability, Bayes theorem.
Random variables and its probability distributions:
Discrete distribution: expected value and standard deviation.
Special discrete distributions: Bernoulli/binomial distribution, Poisson, hypergeometric.
Poisson approximation to binomial distribution.
Continuous distributions: expected value and standard deviation.
Special continuous distributions: uniform distribution, normal, Chi-square distribution, *F* distribution.
Normal approximation to binomial distribution, Poisson.
Sampling distributions: mean, proportions and variance of one and two samples, applications of central limit theorem.
Estimation: point estimation, interval estimation for mean, proportions and variance of one and two populations.
Hypothesis testing: mean, proportions and variance of one and two populations.
Chi-square test: multinomial distribution and test of goodness of fit,
Contingency table: test of independence and test of homogeneity.
Tests based on binomial distribution: sign test and Cox-Stuart test.
Tests based on rank: Wilcoxon sign rank test and Mann-Whitney test.
Run tests: Wald Wolfowitz test, Fisher exact test, Tukey quick test, Mc Nemar test.

Course Outcomes
Upon completion of this course, students are able to
1. identify different types of data and the appropriate way to manage each type of data
2. describe data graphically and numerically and communicate their meanings in general
3. identify the appropriate statistical methods to be used in making inferences about one and two populations based on information from relevant samples
4. perform data analysis correctly and make appropriate decisions and conclusions in solving problems
5. differentiate between situations that are suitable for the application of parametric methods and non-parametric methods.

Reference Books
1. Freund, J. (2003). *"Modern Elementary Statistics"*, Prentice Hall.
2. Seber, G.A.F., Alan, J.L. (2003). *"Linear Regression Analysis"*, J. Wiley.

3. Freund, J.E. & Perles, B.M. (1999). *"Statistics: A First Course"*, Prentice Hall.

6. MAA 161/4 Statistics for Science Students

Numerical and graphical description of data.
Empirical law and Chebyshev theorem.
Introduction to probability: concept of probability, counting techniques, rules of probability, independence, conditional probability, Bayes theorem.
Random variables and its probability distributions:
Discrete distribution: expected value and standard deviation.
Special discrete distributions: Bernoulli/Binomial distribution, Poisson, hypergeometric.
Poisson approximation to binomial distribution.
Continuous distributions: expected value and standard deviation.
Special continuous distributions: uniform distribution, Normal, Chi-square distribution, *F* distribution.
Normal approximation to binomial distribution, Poisson.
Sampling distributions: mean, proportions and variance of one and two samples, applications of central limit theorem.
Estimation: point estimation, interval estimation for mean, proportions and variance of one and two populations.
Hypothesis testing: mean, proportions and variance of one and two populations.
Chi-square test: multinomial distribution and test of goodness of fit,
Contingency table: test of independence and test of homogeneity.
Tests based on binomial distribution: sign test and Cox-Stuart test.
Tests based on rank: Wilcoxon sign rank test and Mann-Whitney test.
Run tests: Wald Wolfowitz test, Fisher exact test, Tukey quick test, Mc Nemar test.

Course Outcomes

Upon completion of this course, students are able to

1. have a clear understanding of the basic concepts of statistics such as probability and random variables
2. differentiate between discrete and continuous random variables and use them appropriately
3. make statistical inferences for population parameters based on sample statistics
4. identify the appropriate parametric and non-parametric methods in making statistical inferences.

Reference Books

1. Freund, J. (2003). *"Modern Elementary Statistics"*, Prentice Hall.
2. McClave & Sincich, T. (2006). *"Statistics"*, Prentice Hall.
3. Prem, S.M. (2005). *"Introductory Statistics"*, J. Wiley.
4. Freund, J.E. & Perles, B.M. (1999). *"Statistics: A First Course"*, Prentice Hall.

7. MAT 102/4 Advanced Calculus

L'Hospital's rule.
Improper integrals.
Sequence and series of numbers:
Monotone convergence theorem for sequence.
Divergence and convergence of series, absolute and conditional convergence, n-th term test, integral test, comparison test, ratio test, root test, alternating series test (may include Raabe test).
Taylor polynomials, Taylor series,
approximation of function by Taylor's polynomial with remainder.
Power series, radius of convergence, interval of convergence, differentiation and integration of power series term by term.
Function of several variables:
Limit and continuity.
Partial derivatives, directional derivatives, total differential, chain rule, partial derivatives for implicit functions.
Maximum and minimum, Lagrange multiplier method.
Multiple integrals, iterated integrals, change of variables.

Course Outcomes
Upon completion of this course, students are able to
1. know about sequences and series of real numbers, and their relationship
2. find series representation for certain basic functions
3. identify different type of improper integrals and determine their convergence
4. know about functions of several variables and the concepts of limit, continuity, derivative and integration of these functions
5. evaluate multiple integral of functions of several variables using the iterated integral or/and transforming into other types of coordinates.

Reference Books
1. Spivak, M. (1994). *Calculus,* 3rd edition. Publish or Perish Inc.
2. Apostol, T.M. (1967). *Calculus,* Vol. I, 2nd edition. John Wiley & Sons.
3. Apostol, T.M. (1969). *Calculus*, Vol. II. John Wiley & Sons.
4. Stewart, J. (2003). *Calculus,* 5th edition. Thomson Brooks/Cole.

8. MAA 102/4 Calculus for Science Students II

Sequence and series of numbers:
Monotone convergence theorem for sequence.
Divergence and convergence of series, *n*-th term test, integral test, comparison test, ratio test, alternating series test.
Improper integral.
Power series:
Taylor series and Maclaurin series, radius and interval of convergence, differentiation and integration of power series term by term.
Taylor polynomials, approximation of function by Taylor's polynomial with remainder.

Function of several variables:
Partial derivatives, directional derivatives, chain rule.
Maximum and minimum, Lagrange multiplier method.
Multiple integrals.
Differential equations:
First order differential equation and methods of solution, applications in economics, biology and chemistry.

Course Outcomes

Upon completion of this course, students are able to

1. determine the convergence of a sequence, series, power series and improper integrals
2. select and use an appropriate test to determine the convergence of the series
3. find the partial derivatives using chain rule, directional derivatives and their applications
4. evaluate a double integral in cartesian and polar coordinates
5. have the methods in first order differential equation to problems in life and physical sciences.

Reference Books

1. Stewart, J. (2003). *Calculus*, 5th edition. Thomson, Brooks/Cole.
2. Strauss, M.J., Bradley, G.L. and Smith, K.J. (2002). *Calculus*, 3rd edition. Prentice-Hall.
3. Weir, M.D., Hass, J. and Giordano, F. R. (2005). *Thomas' Calculus*, 11th edition. Pearson Addison Wesley.

9. MAT 122/4 Differential Equations I

Ordinary differential equations: linear and nonlinear, homogeneous and nonhomogeneous, degree and order. The existence and uniqueness theorem.
First order equations: introduction to standard solution techniques.
Second order equations with constant coefficients. Standard methods for solving homogeneous and nonhomogeneous equations.
Numerical methods : Euler's method and Heun's method, simple error analysis.
Power series solutions: ordinary points only.
Systems of first order linear equations: introduction.
Applications: economics, ecology, etc.
Software: usage of standard software such as MATLAB is encouraged.

Course Outcomes

Upon completion of this course, students are able to

1. understand fundamental concepts and theory of differential equations (DE) and able to apply DE procedures in routine and non-routine concepts
2. select and use appropriate DE strategies and techniques
3. demonstrate an understanding of the appropriate use of DE modelling
4. gain computational skills needed in understanding applied problems
5. have quantitative reasoning skills, conceptual understanding and are able to effectively communicate in mathematics.

Reference Books

1. Edwards, C. H. & Penney, D. E., (2004). *Differential Equations and Boundary Value Problems: Computing and Modeling*, 3rd edition. Upper Saddle River, NJ: Pearson Education.
2. Zill, D.G. & Cullen, M. R., (2005). *Differential Equations with Boundary Value Problems*, 6th edition. Toronto:Thomson/Brooks/Cole.
3. Boyce, W.E. & DiPrima, R.C., (2005). *Elementary Differential Equations & Boundary Value Problems*, 8th edition. Pacific Grove: John Wiley & Sons.

10. MSG 162/4 Applied Statistical Methods

Introduction to Experimental Design
Elements of experimental design. Principles of experimental design: Replication, randomization, local control.
Test to compare several means of treatments: Analysis of Variance
Completely randomized design. Test for equality of k variances. Orthogonal contrast. Post-hoc contrasts: the least significant difference method, Duncan's multiple range test, Bonferroni test, Scheffe's test, Tukey's test and Dunnett's test for comparing treatment means with a control. Randomized complete block design and Latin square design. Analysis of variance for unbalanced design.
Non-parametric tests: Kruskall-Wallis test, median test, Friedman test and Cochran test.
Applied linear regression
Correlation coefficient: Pearson. Non-parametric tests: Spearman and Kendall test.
Simple linear regression model: Least squares method, residual analysis, coefficient of determination, significance tests, interpreting coefficients, estimation and prediction.
Multiple linear regression model: Multicollinearity, identification of outliers and influential observations.
Analysis of variance approach to regression analysis.

Course Outcomes
Upon completion of this course, students are able to

1. identify the different basic designs of an experiment
2. check for model assumptions
3. select and apply the appropriate statistical technique for an experimental design
4. differentiate between a parametric test and a non-parametric test
5. analyze data for regression models.

Reference Books

1. Montgomery, D.C. (2000). *Design and Analysis of Experiments*, Wiley.
2. Ott, R.L. and Longnecker, M. (2001). *An Introduction to Statistical Methods and Data Analyis*, 5th edition. Duxbury.
3. Seber, G.A.F. and Alan, J.L. (2003). *Linear Regression Analysis*, Wiley.

11. MAT 181/4 Programming for Scientific Applications

Introduction to basic computer concepts: computer hardware and software. A brief introduction to programming concepts. Problem solving and program design.
Introduction to C^{++} language: writing simple C^{++} programs but comprehensive. Program control structures: sequence, selection and repetition. Basic C++ operators. Output formatting.
Modular programming: functions. Strategies in solving complex problems.
File processing.
Advanced data types: arrays. Pointers. Enumerations and structures. Strings. Classes and object oriented programming.

Course Outcomes
Upon completion of this course, students are able to
1. understand fundamental computer programming concepts and algorithm development in problem-solving
2. apply appropriate programming techniques/structures and strategies in transforming the description of a problem into executable computer codes
3. solve problems in mathematics and scientific applications using a computer programming language
4. develop programs using advanced programming structures (modular programming, files manipulation, pointers) which add values to the computer programs.

Reference Books
1. Bronson Gary J. (2006) *"A First Book of C++: From Here to There"*, 3rd edition, Course Technology, Thomson Learning, Australia.
2. Cannon Scott (2001). *"Understanding Programming: An Introduction Using C++"*, 2nd edition. Brooks Cole.
3. Malik D.S. (2002). *"C++ Programming: From Problem Analysis To Program Design"*, Course Technology, Thomson Learning.

12. MAT 202/4 Introduction to Analysis

Real numbers:
algebraic and order properties, infimum and supremum,
completeness axiom, the extended real number system.
Countability of sets.
Metric spaces:
limit point, interior point, closed and open sets, compact sets,
Bolzano-Weierstrass theorem, Heine Borel theorem, Cantor set,
connected set.
Sequence and series of numbers:
convergent sequence, subsequence, Cauchy sequence, upper and lower limits, absolutely convergent series, addition and multiplication of series, rearrangements.
Continuity:
limit of a function, continuous function, continuity and compactness,

continuity and connectedness, discontinuities, monotonic functions.
Sequence and series of functions:
pointwise convergence and uniform convergence, interchange of limits, equicontinuous families of functions, Stone-Weierstrass theorem.

Course Outcomes
Upon completion of this course, students are able to
1. have a firm understanding of the real number system and its topological properties
2. state mathematical definitions precisely, illustrate them with examples, and use them in writing proofs
3. relate topics from calculus such as limit and continuity from a more advanced viewpoint
4. construct mathematical proofs using mathematical logic.

Reference Books

1. Rudin, W. (1976). *Principles of Mathematical Analysis*, 3rd edition. McGraw Hill.
2. Apostol, T.M. (1974). *Mathematical Analysis*, 2nd edition. Addison-Wesley.
3. Goldberg, R.R. (1976) *Methods of Real Analysis*, 2nd edition. John Wiley & Sons.

13. MAT 203/4 Vector Calculus

Vectors:
Vector product, triple product, linearly independent vectors, analytic geometric vector.
Vector function:
Curve, arc length, tangential vector, Frenet's formula, curvature, torsion.
Differential:
Limit, continuity, partial differentiation, differential, directional differentiation, tangent, chain rule, mean value theorem, Taylor's theorem for function of several variables, divergence, curl.
Inverse function theorem, implicit function theorem, global inverse, curvilinear coordinates, and extreme values.
Integration:
Iterated integration, double integration, line integration, independent path, Green's theorem, surface integration, divergence theorem, Stoke's theorem, change of variables in multiple integration.

Course Outcomes
Upon completion of this course, students are able to
1. evaluate scalar, vector and triple products and their uses in the description of lines and planes
2. analyze the differential geometry of 3-dimensional curves
3. evaluate the gradient, divergence and curl of scalar and vector fields in terms of cartesian, cylindrical and spherical coordinates
4. evaluate line, surface and volume integrals

5. state and use Green’s theorem in the plane, divergence theorem and Stokes’ theorem.

Reference Books

1. Colley, S.J. (2005). *Vector Calculus,* 3rd edition. Pearson Prentice Hall.
2. Matthews, P.C. (1998). *Vector Calculus,* Springer-Verlag.
3. Marsden, J.E. and Tromba, A.J. (2003) *Vector Calculus*, W.H. Freeman and Co.

14. MAT 222/4 Differential Equations II

Advanced theory on system of differential equations and its solutions: focus will be given on methods for solving nonhomogeneous systems, autonomous system and its stability.
Orthogonal function, Fourier series and the Sturm-Liuoville problem.
Partial differential equations: some introduction to partial differential equations that are normally used to solve problems in mathematical physics and methods for solving these equations.

Course Outcomes

Upon completion of this course, students are able to

1. solve problems involving linear system of equations, both homogeneous and non-homogeneous
2. analyze the local stability of plane autonomous systems
3. interpret series expansion of functions based on infinite set of orthogonal functions into the solution of Sturm-Liouville problem
4. solve partial differential equations using separation of variables
5. analyze solutions of boundary-value problems for different forms of boundary and intial values.

Reference Books

1. Boyce, W.E. & DiPrima, R.C., (2005). *Elementary Differential Equations & Boundary Value Problems,* 8th edition. Pacific Grove: John Wiley & Sons.
2. Andrews L.C., (1986). *Elementary Partial Differential Equations with Boundary Value Problem*, Academic Press.
3. Zill, D.G. & Cullen, M.R., (2005). *Differential Equations with Boundary Value Problems,* 6th edition. Toronto: Thomson/Brooks/Cole.

15. MAT 251/4 Introduction to Operations Research

Scientific methods and operations research. Applications of operations research in decision analysis.
Linear programming: modelling, graphical solution, standard form and simplex method. Sensitivity analysis.
Transportation and assignment problems.
Project scheduling: PERT-CPM. Project crashing. Project planning.
Exposure to some relevant software packages.

Course Outcomes

Upon completion of this course, students are able to

1. formulate problem into a linear programming model
2. choose and use a suitable method to solve a problem
3. do the economic interpretation of the optimal solution and do the sensitivity analysis.

Reference Books

1. Taha, H.A. (2007). *Operations Research: An Introduction*, 8th edition. New Jersey: Prentice Hall.
2. Muhammad Jantan. *Pengantar Penyelidikan Operasi*, Siri Edisi Awal. Pulau Pinang: Penerbit USM.
3. Norman, J. and Titchie, E. (1981). *Problem Solving Exercise In OR*, Lancaster Lancord.

16. MSG 262/4 Quality Control

Seven tools for statistical quality control: check sheet, histogram, Pareto diagram, cause-and-effect diagram, stratification, scatter diagram and control charts.

Statistical process control: control charts $\overline{X} - R, \overline{X} - S$, median-range, EWMA, CUSUM, *p*, *np*, *c* and *u*. Specification limits. Process capability.

Acceptance sampling plans. Producer risk and consumer risk. Single sampling plan. Double sampling plan. Operating characteristic curve of a sampling plan, MIL-STD 105E and Dodge-Romig sampling plans.

Course Outcomes

Upon completion of this course, students are able to

1. define and describe the concepts of quality, total quality management (TQM) and quality control (QC)
2. apply both graphics and quantitative quality measurement and quality analysis tools
3. analyze, interpret and solve quality-related problems
4. work as a team to solve quality related issues
5. communicate orally and in written form pertaining to quality.

Reference Books

1. Besterfield, D.H. (2004). *Quality Control,* 7th edition., New Jersey, U.S.A : Pearson Prentice Hall.
2. Montgomery, D.C. (2005). *Introduction to Statistical Quality Control,* 5th edition. U.S.A : John Wiley & Sons.
3. Oakland, J.S. (1996). *Statistical Process Control,* 3rd edition. Oxford, U.K. Butterworth-Heinemann

17. MAT 263/4 Probability Theory

Probability: expansion of the axioms of probability, the concept of mutually exclusive and independence, conditional probability. Bayes theorem.

Random variables, probability density function and distribution function, expectation and moment generating function, Markov and Chebyshev inequality, law of large numbers, distribution function of random variables.
Some special distribution: Bernoulli, binomial, Poisson, hypergeometric, negative binomial, uniform, normal, exponential, chi-square, gamma, beta.
Bivariate random variables: density function and joint distribution function, conditional probability density function and distribution function, covariance, conditional expectation, independence of two random variables, bivariate normal random variables.
1-1 transformation. Sampling distribution: Chi-squares, t and F. Central limit theorem.

Course Outcomes

Upon completion of this course, students are able to

1. define probability and prove basic theorems in probability
2. find the probability density function(*p.d.f.*) and distribution function (*d.f.*) of any random variables (*r.v.*) and hence, obtain the mean, variance, moment generating function and the k-th moment from this *p.d.f.* or *d.f.*
3. identify daily problem that can be solved in terms of *r.v.* and the properties of its distribution
4. examine problems of joint and conditional *p.d.f.*'s and *d.f.*'s and their moments and determine the dependence between two r.v's
5. develop distributions of sample mean and variance from a normal distribution and distribution of functions of two or more *r.v.*'s.

Reference Books

1. Hogg, R.V. and Craig, A.T. (1995). *Introduction to Mathematical Statistics*, 5th edition. Prectice Hall.
2. Hogg, R.V. and Tanis, E.A. (2001). *Probability and Statistical Inference,* 6th edition. Prectice Hall.
3. Ross, S. (2006). *A First Course in Probability,* 7th edition. Pearson Prentice Hall.

18. MAT 282/4 Engineering Computation I

Introduction to basic numerical methods: rounding errors and computer arithmetic.
Solution of non-linear equations.
Solution of linear systems of equations: direct methods and iterative methods.
Solution of non-linear systems of equations.
Polynomial interpolation.
Numerical differentiation and integration.
Numerical methods to compute eigenvalues and eigenvectors.

Course Outcomes

Upon completion of this course, students are able to

1. apply numerical methods to solve a given non-linear equation and state the general conditions which guarantee the convergence of the methods
2. construct interpolating polynomials for a given set of data

3. state and analyze the formulas for error in polynomial interpolation
4. apply numerical integration and differentiation to find an approximate value of an integral
5. construct and apply formulas to approximate specific derivatives of functions by differentiating appropriate interpolating polynomials.

Reference Books

1. Fausett, L.V. (1999). *"Applied Numerical Analysis Using MATLAB"*, Prentice-Hall.
2. Cheney, E.W. and Kincaid, D.R. (2004). *"Numerical Mathematics and Computing"*, 5th edition. Thomson.
3. Schilling, R.A. and Harris, S.L. (2000). *"Applied Numerical Methods For Engineers Using MATLAB"*, Thomson.

19. MSG 228/4 Introduction to Modelling

The aims of this course are to:

(a) expose students to the basic concepts and methodology in modelling.

(b) introduce standard mathematical tools in modelling.

Topics include:

(i) interpreting graphs (ii) optimization (iii) ordinary differential equations (iv) data analysis (v) difference equations (vi) simulation.

Areas of interest may consist of biology, environment, engineering, and economics.

Course Outcomes

Upon completion of this course, students are able to

1. build a simple mathematical model from a verbal description or a tabular data
2. demonstrate understanding of methods, skills and tools used in a variety of models
3. interpret models and solutions (if appropriate) and draw inferences from them
4. recognise and use the connections between mathematics and other disciplines.

Reference Books

1. Frank, R. Giordano, Maurice, D. Weir, Williams P. (2003). *Fox; A First Course in Mathematical Modeling,* 3rd edition. Brooks-Cole.
2. Frederick, R. Marotto (2005). *Introduction to Mathematical Modeling using Discrete Dynamical System:* Brooks-Cole.
3. Beltrami, E. (2001). *Mathematical Models for Society and Biology,* Academic Press.

20. MSG 252/4 Linear and Integer Programming

Linear programming: revised simplex method. Duality theory. Dual simplex method. Sensitivity analysis.

Integer programming model: pure integer and mixed integer model, 0-1 model, cutting plane technique, branch and bound method. Implicit enumeration.
Goal programming: formulation and solution.
Applications to practical problems. Exposure to relevant software packages.

Course Outcomes

Upon completion of this course, students are able to

1. detect the similarities and differences between simplex and revised simplex methods
2. apply the duality theory to any linear programming problem
3. use any of the techniques tought in this course to solve linear and integer programming problems
4. formulate a goal programming problem and find its solution using suitable methods.

Reference Books

1. Che Rohani Yaacob (2001). *Pengaturcaraan Linear dan Integer,* Penerbit USM.
2. Taha, H.A. (1992). *Operations Research An Introduction,* New York: Macmillan.
3. Winston, W.L. (1993). *Operations Research Applications and Algorithms.* Belmont, California: Duxbury.

21. MSS 211/4 Modern Algebra

Sets: subsets, equality of sets, universal set, null set, Venn diagram, intersection of sets, union of sets, difference of two sets, complement of a set, de Morgan's theorem, family of sets, ordered pairs, product of sets.
Relations: image sets, reflexive relations, symmetric relations, transitive relations, equivalence relations, equivalence classes, partitions, divisibility of an integer, congruence, congruence classes modulo *n*.
Functions (defined as specialized relations): mappings, injective functions, surjective functions, bijective functions, composition of functions, inverse of a function.
Binary operations (defined as specialized functions): commutativity, associativity, left and right identities, identities.
Groups: definition of groups, Abelian groups, identity element, inverse of an element.
Permutations: bijective permutations on a finite set as elements of a symmetric group, cycles, transpositions, disjoint cycles, odd and even permutations, alternating groups.
Subgroups: proper subgroups, trivial subgroup, order of an element, cyclic groups, generators, subgroups generated by a set.
Cosets and normal subgroups: order of a group, right and left cosets, Lagrange's theorem, normal subgroups, factor groups.
Homomorphism: homomorphism, isomorphism, endomorphism, automorphism, kernels.

Rings: unity element, zero element, commutative rings, integer domain, zero divisor, division rings, fields, quaternion rings, subrings, ideals, factor rings, homomorphism and isomorphism of rings.

Course Outcomes

Upon completion of this course, students are able to

1. prove whether a given binary system is a group, whether it is an Abelian group or cyclic group
2. differentiate between the structured properties and non-structured properties of a group when they prove the isomorphism of groups
3. list all elements in a group after the generators are given
4. construct factor groups by using homomorphism or normal subgroups
5. give examples that can clearly differentiate between rings, rings with unity, commutative rings, non-commutative rings, integral domains, division rings, fields, finite fields.

Reference Books

1. Durbin, J. R. (2005). *Modern Algebra, An Introduction*, John Wiley and Sons, Inc.
2. Fraleigh, J. B. (1993). *A First Course in Abstract Algebra*, Addison-Wesley Publ. Com.
3. Lim, E. B. and Ng, S. N. (1987). *Aljabar Moden*, Penerbit USM Pulau Pinang.

22. MSS 212/4 Further Linear Algebra

Determinant: definition of determinant using permutation, properties and evaluation of determinants.

Vector space: abstract vector space, linear independence, bases, dimensions.

Linear transformation: linear transformation and its matrix representation relative to an ordered basis, dual space, isomorphism of vector spaces, eigenspace and diagonalizability.

Inner product space: spectral theorem and quadratic form, positive definite, adjoint of a linear transformation, self-adjoint linear transformation.

Jordan canonical form: the minimal polynomial, the characteristic polynomial, Caley Hamilton theorem, quotient space, Jordan canonical form.

Course Outcomes

Upon completion of this course, students are able to

1. demonstrate how linear transformations can be used in solving problems regarding matrices
2. describe how properties of determinant, the co-factor expanding formula and Cramer's rule are deduced from the permutation definition of determinant
3. identify vector spaces over □ together with its respective dimension and determine which vector spaces are isomorphic by constructing isomorphism

4. determine whether a given linear transformation (or matrix) is diagonalizable or not and find a basis that will give the Jordan canonical form of the respective linear transformation (or matrix)
5. identify self-adjoint linear transformation and apply the spectral theorem to find an orthonormal basis that will diagonalize the respective self-adjoint transformation.

Reference Books

1. Smith, L. (1998). *Linear Algebra*, 3rd edition. Springer-Verlag.
2. Friedberg, S.H., Insel, A.J. and Spence, L.E. (2003) *Linear Algebra*, 4th edition. Prentice Hall.
3. Gelfand, I.M. (1950) *Lectures on Linear Algebra*. Dover Publication.

23. MSS 281/2 Mathematical Software Laboratory I

Introduction to the capabilities of the MATLAB software package for interactive numeric and symbolic computation, data analysis and graphics.

The use of MATLAB as an aid to solve and explore a variety of mathematical problems and applications.

Course Outcomes

Upon completion of this course, students are able to

1. understand the basic and usage of MATLAB
2. demonstrate MATLAB for solving any mathematical problems
3. produce a project on mathematical problems using the knowledge in MATLAB.

Reference Books

1. Ahmad, N. A., Hasan, Y. A., Zainuddin, Z. & Low H. C., (2002). *MATLAB: Pendekatan Penyelesaian Masalah Matematik*, Kuala Lumpur: McGraw Hill.
2. Davis, T.A. & Sigmon, K., (2005). *MATLAB Primer*, 7th edition. Boca Raton:Chapman & Hall.
3. Law, A., (2004). *Introduction to Scientific Computing using MATLAB*, Upper Saddle River:Pearson Prentice Hall.
4. Golubitsky, M. & Dellnitz, M., (1999). *Linear Algebra and Differential Equations using MATLAB*, Australia:Thomson/Brooks/Cole.

24. MSS 282/3 Mathematical Software Laboratory II

Introduction to the Mathematica software for solving and investigating mathematical problems.
The use of Mathematica as a tool for solving and investigating mathematical problems.
Computational laboratories in Mathematica for vector calculus.

Course Outcomes

Upon completion of this course, students are able to

1. interpret and explore scalar functions, vector functions, scalar operations and vector operations using Mathematica
2. relate algebraic and geometrical descriptions of 2-D and 3-D curves, scalar fields and their level curves/surfaces, vector fields and their corresponding flow lines, as well as able to generate these descriptions in Mathematica
3. solve problems involving quantities such as directional derivatives, divergence, curl, laplacian, line and surface integrals using Mathematica
4. interpret several fundamental theorems on conservative vector fields.

Reference Books

1. http://www.physics.umd.edu/courses/CourseWare/EssentialMathematica/.
2. http://www.math.tarleton.edu/Faculty/white/calclab/labbk.html
3. http://www.ma.iup.edu/projects/calcDEMma/vecdcalc/vecdiffcalc.html
4. Ahmad, N.A., (2004). *Menyelesaikan Masalah Matematik Menggunakan Mathematica*-Kompilasi Nota.

25. MAT 363/4 Statistical Inference

Revision of probability theory. Sampling distributions, order statistics, limiting distribution, stochastic convergence.

Point estimation: properties of estimators - consistency, unbiasedness, efficiency and sufficiency. Point estimation using the method of maximum likelihood and the method of moments. Completeness property for a family of distributions. Unbiased estimators with minimum variance.

Interval estimation: confidence intervals for small and large samples. Pivotal quantity.

Hypothesis testing: statistical hypothesis, types and sizes of errors, power function, critical region, most powerful test, fundamental lemma of Neyman-Pearson, uniformly most powerful test, likelihood ratio tests for testing the mean, variance, equality of two means and equality of two variances for normal distribution, analysis of variance, non-parametric statistics, goodness-of-fit tests.

Course Outcomes

Upon completion of this course, students are able to

1. have a firm understanding of probability theory and statistical inference
2. find the distributions and joint distributions of random variables and random vectors
3. derive point estimators and construct confidence intervals
4. conduct testing of hypotheses to verify claims.

Reference Books

1. Khatijah, S.A. (1995). *"Pengantar Teori Statistik*, "Penerbit USM".
2. Hogg, R.V., Craig, A.T. (1978). *"Introduction to Mathematical Statistics"*, 4th edition. New York, Macmillan.
3. Miller, I. & Miller, M. (2004). *"Mathematical Statistics with Application"*, 7th edition. New Jersey: Pearson Prentice Hall.

26. MSG 322/4 Fluid Mechanics

Review of vector calculus.
Basic statics.
Basic concept of fluid dynamics and kinematics.
Finite control volume analysis of fluid flow.
Differential analysis of fluid flow.
Two-dimensional motion (potential flow theory).
Flow through pipes.
Basic concept of boundary layer theory.
Open channel flow.

Course Outcomes
Upon completion of this course, students are able to
1. state the definition of a fluid and related concepts such as viscosity, compressibility, laminar/turbulent flows
2. formulate the governing equations of fluid mechanics using a finite control volume and an infinitesimally small fluid element model
3. distinguish different types of flows and apply the relevant equations to compute quantities of interest.

Reference Books

1. Merle, C. Potter and David, C. Wiggert (2003). *Mechanics of Fluid,* 3rd edition. Brooks/Cole.
2. Fox, R.W. and McDonald, A.T. (2004) *Introduction to Fluid Mechanics*, 5th edition. John Wiley.
3. Frank, M. White *Fluid Mechanics* 5th edition. McGraw Hill.

27. MSG 356/4 Mathematical Programming

Introduction: review of differential calculus, basic concepts in optimization theory, including extremum (maximum and minimum), optimality criteria and convexity.
Non-linear programming problems (NLPs): definition and formulation, techniques used to solve NLPs with one and several variables, unconstrained and constrained problems including the golden section search, the method of steepest ascent, the Newton-Raphson method, the Lagrange multiplier, the Kuhn-Tucker method, quadratic programming, separable programming, the method of feasible directions, geometric programming.
Introduction to dynamic programming and its applications to sequential decision problems.
Exposure to some relevant software packages. Case studies.

Course Outcomes
Upon completion of this course, students are able to
1. recognise the differences between linear programming problems (LPs) and non-linear programming problems (NLPs)

2. formulate the real problems to NLPs
3. solve NLPs using the appropriate techniques
4. interpret the solutions and making inferences from the results
5. use software packages to solve NLPs and interpret the software output.

Reference Books

1. Winston. W.L. and Venkataramanan, M. (2003). *Introduction to Mathematical Programming*, 4th edition. Duxbury.
2. Taha, H.A. (2003). *Operations Research: An Introduction*, 7th edition New Jersey: Prentice Hall.
3. Wismer, D.A. and Chattergy, R. (1978). *Introduction to Nonlinear Optimisation: A Problem Solving Approach*, North-Holland: Elsevier.
4. Bazaraa, M.S., Sherali, H.D. and Shetty, C.M. (1993). *Nonlinear Programming: Theory and Algorithms*, 2nd edition. New York, John Wiley.

28. MSG 389/4 Engineering Computations II

Ordinary Differential Equations.
Initial Value Problems: single-step and multi-step methods. System of equations and higher order equations.
Boundary value problems: shooting method, finite segment and finite difference methods.
Partial Differential Equations.
Parabolic equations: FTCS and Crank Nicolson method. Consistency, stability and convergence.
Hyperbolic equations: method of characteristics and finite difference methods for the wave equation.
Elliptic equations: standard finite difference schemes for Poisson equation. Solution of resulting systems of linear equation.

Course Outcomes

Upon completion of this course, students are able to

1. recognize and solve IVP for ODE by analytical and numerical methods such as RK2 and RK4
2. formulate and solve real life problem simulations such as lake and river pollution by BVP for PDE
3. design and implement efficient codes FORTRAN to solve real life problem simulations for ODE and PDE
4. interpret and synthesize simulation results.

Reference Books

1. Fausett, L.V. (1999). *"Applied Numerical Analysis Using MATLAB"*, Prentice-Hall.
2. Cheney, E.W. and Kincaid, D.R. (2004) *"Numerical Mathematics and Computing"*, 5th edition. Thomson.
3. Schilling, R.A. and Harris, S.L. (2000) *"Applied Numerical Methods For Engineers Using MATLAB"*, Thomson.

29. MSS 301/4 Complex Analysis

Complex number: definition, algebraic properties, polar and exponential forms, power and roots.
Analysis of functions: complex valued functions, mapping, limits continuity, derivatives, Cauchy-Riemann equations, analytic functions, harmonic functions.
Elementary function: exponential function, trigonometric and hyperbolic, logarithmic function and its branches, complex exponents, inverse function, Mobius transformations.
Integration: define integrals, line and contour integrals, Cauchy theorem, simply and multiply connected domains, independence of paths, Cauchy integral formula, derivatives of analytic function, maximum modulus principle, Liouville's theorem, fundamental theorem of algebra.
Series: Taylor and Laurent series, uniform convergence, integration and differentiation of power series, zeros of analysis function, singularities and poles.
Residues: residue theorem, calculus of residues, integrals of trigonometric and rational functions, indented contour integrals, integration around branch points.

Course Outcomes

Upon completion of this course, students are able to

1. have a firm understanding of the structure of the complex plane, and the basic concepts and theory of analytic functions of a complex variable
2. differentiate functions, evaluate contour integrals, and determine convergence of series
3. construct rigorous arguments and proofs, as well as demonstrate applications of several key theorems
4. demonstrate the inter-relationship as well as several interesting differences between functions of a real and a complex variable
5. write mathematical reports and assignments.

Reference Books

1. Silverman, R.A. (1984). *Complex Analysis with Applications.* Dover Publications.
2. Ahlfors, L.A. (1979). *Complex Analysis*, 3rd edition. McGraw-Hill.
3. Marsden, J.E. (1973). *Basic Complex Analysis*. W. H. Freeman.
4. Brown, J.W. and Churchill, R.V. (2004). *Complex Variables and Applications,* 7th edition. McGraw Hill.

30. MSS 302/4 Real Analysis

Function of several variables: differentiation, mean value theorem, Taylor's formula, Jacobian, inverse function theorem, implicit function theorem, derivatives of higher order, differentiation of integrals.
Lebesgue theory: set functions, construction of the Lebesgue measure, measurable functions, Lebesgue integral, the three principles of Littlewood, monotone convergence theorem, dominated convergence theorem, comparison with the Riemann integral, Cauchy Riemann criterion, Lebesgue criterion, functions of class L^2.

Course Outcomes

Upon completion of this course, students are able to

1. firmly recognize the weakness of the theory of Riemann integral and to realize the need to have a better theory
2. describe the concept of measurability
3. demonstrate examples about several key theorems
4. recognize the differences between the two integral theories: Riemann integral and Lebesgue integral
5. write mathematical reports and assignments.

Reference Books

1. Rudin, W. (1976). *Principles of Mathematical Analysis*, 3rd edition. McGraw Hill.
2. Royden, H.L. (1988). *Real Analysis*, 3rd edition. Maxwell Mcmillan.
3. Bartle, R.G. (1975). *The Elements of Real Analysis*, 2nd edition. John Wiley & Sons.
4. Apostol, T.M. (1974). *Mathematical Analysis*, 2nd edition. Addison-Wesley.
5. Bartle, R.G. (1966). *The Elements of Integration*, John Wiley & Sons.

31. MSS 317/4 Coding Theory

Basic error detection, correction and decoding principles: maximum likelihood decoding, Hamming distance, nearest neighbour / minimum distance decoding, distance of a code.

Finite fields: basic properties of fields and finite fields, polynomial rings, construction and structure of finite fields, minimal polynomials and cyclotomic cosets.

Linear codes and vector spaces over a finite field: Hamming weight, generating matrices, parity check matrices, standard array decoding and syndrome decoding.

Important families of linear codes: Hamming code, Golay code.

Bounds on codes: relation between the 3 important parameters of a code – n (the length of the code), M (the size of the code), d (the distance of the code), Hamming (sphere-packing) bound, Plotkin bound, Singleton bound, optimal codes and some construction of these codes.

Cyclic codes and ideals of a ring: generating polynomials, cyclic decoding algorithm, examples of cyclic codes: cyclic Hamming codes, BCH (Bose, Chaughuri, Hocquengham) code, Reed Solomon code.

Course Outcomes

Upon completion of this course, students are able to

1. construct examples to show how codes can be used in improving the reliability of communication channels
2. explain the need of encoding process and the mechanism of how decoding process can be used in detecting and correcting errors
3. construct finite fields using irreducible polynomial and quotient polynomial rings

4. construct linear codes (i.e. generating matrix and parity check matrix) and cyclic codes (i.e. generator polynomial and check polynomial) and determine the relation of generating matrix and generator polynomial and also the relation of parity check matrix and check polynomial
5. construct optimal codes.

Reference Books

1. Hill, R. (1986). *A first course in Coding Theory*, Oxford Press.
2. Ling, S. and Xing, C. (2004). *Coding Theory – a first course*, Cambridge University Press.
3. McWilliams, F. and Stone, N. (1977). *The theory of Error Correcting Codes*, North-Holland.

32. MSS 318/4 Discrete Mathematics

Combinatorics: pigeon-hole principle, counting techniques, permutations and combinations, inclusion and exclusion principle, recurrence relations and generating functions.
Graph theory: Eulerian and Hamiltonian graphs, connectivity, planarity, colouring, digraphs.

Course Outcomes

Upon completion of this course, students are able to

1. identify discrete methods that stress on the finite nature inherent in many problems and structures
2. apply and use the tools learnt in counting techniques using their own creativity
3. construct graph models by identifying and categorizing phenomena in other areas of study that admit such a modelling
4. efficiently solve problems that require mathematical reasoning and analysis
5. prepare well-written reports reflecting their mathematical thinking.

Reference Books

1. Bogart, K.P. (1988). *Discrete Mathematics*, Heath, D.C. Lexington.
2. Tucker, A. (1995). *Applied Combinatorics*, 3rd edition. John Wiley, New York.
3. Rosen, K.H. (1988). *Discrete Mathematics and its Applications,* Random House, Cambridge.
4. Grimaldi, R.P. (1999). *Discrete and Combinatorial Mathematics: An Applied Introduction*, 5th edition. Addison-Wesley, Reading.

33. MSS 392/4 Minor Project

The objective of this course is to give an opportunity for independent work by students on a particular topic relevant to the B.Sc. Program.

Course Outcomes

Upon completion of this course, students are able to

1. carry out a short research project
2. conduct a meaningful discussion on a topic
3. articulate their research findings verbally and in written form.