SCHOOL OF MATHEMATICAL SCIENCES

INTRODUCTION

The Bachelor of Applied Science degree program in this School was introduced in the 1987/88 Academic Session. The program emphasizes the applications of mathematics and gives emphasis to computing in the study of mathematical sciences. This is to produce graduates who are capable of carrying out research and development works in industries as well as in public and private agencies.

The School offers five areas of specialization:

(i) Applied Statistics
(ii) Operations Research
(iii) Computer Modelling
(iv) Mathematical Modelling
(v) Mathematics and Economics

The above specializations were created in an effort to produce trained graduates in areas of applied mathematical sciences to support the nation's manpower need. The courses have been structured to provide a specialized and solid applied mathematical sciences education. The skills acquired provides a solid foundation for further development of mathematical skills.

VISION

To be a recognised 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 aspiration of society; the country's vision and universal aspirations.

PROGRAMME LEARNING OUTCOMES

BACHELOR OF APPLIED SCIENCE (MATHEMATICAL MODELLING)

At the end of the program, the student is

1. knowledgeable in the fundamentals of mathematical sciences and competent in the application of mathematical modelling to science and engineering.
2. capable of identifying, formulating, analyzing and solving problems in science and engineering, skilled in computer programming, computational techniques and ICT.
3. a team player who is accountable and responsible.
4. professional, responsible and ethical.
5. an effective and confident communicator.
6. a critical thinker who adopts a scientific approach towards solving problems.
7. capable of improving his or her mathematical knowledge as part of a life long learning process.
8. a skilled and innovative leader and manager of resources.

BACHELOR OF APPLIED SCIENCE (COMPUTER MODELLING)

At the end of the program, the student is

1. knowledgeable in the fundamentals of mathematical sciences and competent in the application of mathematical modelling to science and engineering.
2. capable of identifying, formulating, analyzing and solving problems in science and engineering, skilled in computer programming, computational techniques and ICT.
3. a team player who is accountable and responsible.
4. professional, responsible and ethical.
5. an effective and confident communicator.
6. a critical thinker who adopts a scientific approach towards solving problems.
7. capable of improving his or her mathematical knowledge as part of a life long learning process.
8. a skilled and innovative leader and manager of resources.

BACHELOR OF APPLIED SCIENCE (APPLIED STATISTICS)

At the end of the program, the student is

1. competent in the fundamental concepts, theories and results of statistics and able to apply skills in statistical reasoning. The student is also competent in a variety of statistical techniques to solve problems.
2. able to identify, formulate, analyze and solve applied and industrial problems through the integration of statistical techniques with other disciplines.
3. able to convey ideas and statistical knowledge clearly and effectively in both written and oral form.
4. able to work collaboratively as part of a team.
5. able to pursue independent study and continuous personal and professional development.
6. able to be a skilled and innovative leader.
7. professional, responsible and ethical.
8. able to identify business and entrepreneurship opportunities.

BACHELOR OF APPLIED SCIENCE (OPERATIONS RESEARCH)

At the end of the program, the student is

1. competent in the fundamental concepts and theories of operations research.
2. able to apply analytical skills and is competent in a variety of operations research techniques to solve problems.
3. able to identify, formulate, analyze and solve applied and industrial problems through the integration of operations research techniques with other disciplines.
4. able to convey ideas and operations research knowledge clearly and effectively in both written and oral form.
5. able to work collaboratively as part of a team.
6. able to pursue independent study and continuous personal and professional development.
7. able to be a skilled and innovative leader.
8. professional, responsible and ethical.

BACHELOR OF APPLIED SCIENCE (MATHEMATICS AND ECONOMY)

At the end of the program, the student

1. understands how mathematical concepts and processes can be used to develop economics and financial knowledge.
2. is able to identify, formulate, analyze and solve economic problems through the integration of mathematical techniques .
3. is able to communicate ideas and knowledge in mathematics and economics clearly and effectively in both written and oral form.
4. is able to work collaboratively as part of a team.
5. is able to pursue independent study and continuous personal and professional development.
6. is able to be a skilled and innovative leader.
7. is professional, responsible and ethical.
8. is able to identify business and entrepreneurship opportunities.

MAIN OFFICERS

DEAN

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DEPUTY DEANS

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

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

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Applied Science (Mathematics and Economics)

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Applied Science (Applied Statistics / Operational Research)

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

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

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Academic Co-ordinator

ASSISTANT REGISTRARS

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Senior Assistant Registrar

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Assistant Registrar

LIST OF ADMINISTRATIVE AND ACADEMIC STAFF
SCHOOL OF MATHEMATICAL SCIENCES

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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

REQUIREMENT OF THE PROGRAM

(a) Specialization in Applied Statistics, Operations Research, Computer Modelling and Mathematical Modelling

Type of Courses	Classification	Units
Core	T	70
Minor / Elective	M / E	20*
University	U	15-18
	Total Number of Units	105-108

* A student who choose 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.

(b) Specialization in Mathematics and Economics

Type of Courses	Classification	Units
Core	T	90 (Mathematics : 50) (Economics : 40)
University	U	15-18
	Total Number of Units	105-108

CORE COURSES

Students in the specialization areas of Applied Statistics, Operations Research, Computer Modelling and Mathematical Modelling must accumulate **70 units** while **90 units** is required for students in Mathematics and Economics:

Applied Statistics

Compulsory (46 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
MSG 162/4	:	Applied Statistical Methods
MAT 251/4	:	Introduction to Operations Research
MAT 263/4	:	Probability Theory
MSG 285/2	:	Statistical Laboratory
MSG 286/2	:	Operations Research Laboratory
MAT 363/4	:	Statistical Inference
MSG 391/6	:	Project

Specialization Options (16 units)

MSG 262/4	:	Quality Control
MSG 265/4	:	Design and Analysis of Experiments
MSG 366/4	:	Multivariate Analysis
MSG 367/4	:	Time Series Analysis
MSG 368/4	:	Sample Survey and Sampling Technique

Operations Research

Compulsory (46 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
MSG 162/4	:	Applied Statistical Methods
MAT 251/4	:	Introduction to Operations Research
MAT 263/4	:	Probability Theory
MSG 285/2	:	Statistical Laboratory
MSG 286/2	:	Operations Research Laboratory
MAT 363/4	:	Statistical Inference
MSG 391/6	:	Project

Specialization Options (16 units)

MSG 252/4	:	Linear and Integer Programming
MSG 253/4	:	Queueing System and Simulation
MSG 354/4	:	Network Flows
MSG 355/4	:	Inventory Control
MSG 356/4	:	Mathematical Programming

Computer Modelling

Compulsory (62 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 203/4	:	Vector Calculus
MAT 222/4	:	Differential Equations II
MAT 282/4	:	Engineering Computation I
MSG 281/2	:	Modelling Laboratory I
MSG 282/2	:	Modelling Laboratory II
MSG 284/4	:	Introduction to Geometric Modelling
MSG 383/4	:	Data Structures for Computer Graphics
MSG 387/4	:	Computer Graphics
MSG 388/4	:	Mathematical Algorithm for Computer Graphics
MSG 391/6	:	Project

Mathematical Modelling

Compulsory (62 units)

MAT 101/4	:	Calculus
MAT 111/4	:	Linear Algebra
MAT 161/4	:	Elementary Statistics
MAT 102/4	:	Advance Calculus
MAT 122/4	:	Differential Equations I
MAT 202/4	:	Introduction to Analysis
MAT 203/4	:	Vector Calculus
MAT 222/4	:	Differential Equations II
MAT 282/4	:	Engineering Computation I
MSG 228/4	:	Introduction to Modelling
MSG 281/2	:	Modelling Laboratory I
MSG 282/2	:	Modelling Laboratory II
MSG 322/4	:	Fluid Mechanics
MSG 327/4	:	Mathematical Modelling
MSG 389/4	:	Engineering Computation II
MSG 391/6	:	Project

Applied Statistics, Operations Research, Computer Modelling and Mathematical Modelling students are also required to acquire 8 units from the following list :

BOM 111/4	:	Biodiversity
BOM 112/4	:	Ecology
CPT 112/4	:	Discrete Structure
CPT 114/4	:	Logic & Applications
KFT 131/3	:	Physical Chemistry I
KOT 121/3	:	Organic Chemistry I
KTT 111/3	:	Non-Organic Chemistry I
KUT 101/2	:	Chemistry Practical I
KUT 102/2	:	Chemistry Practical II
ZCA 101/4	:	Physics I (Mechanics)
ZCA 102/4	:	Physics II (Electricity & Magnetism)

Mathematics and Economics

Compulsory Mathematics Courses (46 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
MSG 162/4	:	Applied Statistical Methods
MAT 251/4	:	Introduction to Operations Research
MAT 263/4	:	Probability Theory
MSG 285/2	:	Statistical Laboratory
MSG 286/2	:	Operations Research Laboratory
MAT 363/4	:	Statistical Inference
MSG 391/6	:	Project

Specialization Options (4 units)

MSG 356/4	:	Mathematical Programming
MSG 367/4	:	Time Series Analysis

Compulsory Economics Courses (24 units)

SKW 104/4	:	Introduction to Economic Issues
SEW 211/4	:	Microeconomics I
SEW 212/4	:	Microeconomics II
SEW 213/4	:	Macroeconomics I
SEW 214/4	:	Macroeconomics II
SEP 221/4	:	Applied Statistics and Econometrics

Specialization Options (16 units)

Choose 1 from 4 of the following courses:

SEU 225/4	:	Development Economics
SEU 226/4	:	Labour Economics
SEU 228/4	:	Malaysian Economics
SEU 229E/4	:	Islamic Economics

Choose 3 from 7 of the following courses:

SEU 322E/4	:	Applied Economics
SEU 323E/4	:	Monetary Economics
SEU 325E/4	:	Economic Planning and Project Analysis
SEU 327E/4	:	Agricultural Marketing and Cooperative Economics
SEU 329E/4	:	Public Sector Economics
SEU 330E/4	:	International Trade
SEU 331E/4	:	International Finance

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 PREREQUISITE AND SEMESTER OF OFFERING

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

Applied Statistics / Operations Research Specialization

No.	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.	MSG 162/4 : Applied Statistical Methods	MAT 161 (S)	2
8.	MAT 251/4 : Introduction to Operations Research	MAT 111 (S) and MAT 161 (S)	1
9.	MAT 263/4 : Probability Theory	MAT 161 (S) and MAT 102 (S)	1, 2
10.	MSG 252/4 : Linear and Integer Programming	MAT 251 (S)	2
11.	MSG 253/4 : Queueing System and Simulation	MAT 263 (S) and MAT 181 (S)	2
12.	MSG 262/4 : Quality Control	MSG 162 (S)	2
13.	MSG 265/4 : Design and Analysis of Experiments	MSG 162 (S)	2
14.	MSG 285/2 : Statistical Laboratory	MSG 162 (S)	1
15.	MSG 286/2 : Operations Research Laboratory	MAT 251 (S)	2
16.	MAT 363/4 : Statistical Inference	MAT 263 (S)	1
17.	MSG 354/4 : Network Flows	MAT 251 (S)	1
18.	MSG 355/4 : Inventory Control	MAT 251 (S)	2
19.	MSG 356/4 : Mathematical Programming	MAT 251 (S)	2
20.	MSG 366/4 : Multivariate Analysis	MSG 285 (S)	1
21.	MSG 367/4 : Time Series Analysis	MSG 285 (S)	2
22.	MSG 368/4 : Sample Survey and Sampling Technique	MSG 162 (S)	2
23.	MSG 391/6 Project	Applied Statistics : MAT 263(S) and MSG 285 (S) Operations Research : MSG 286 (S)	1 and 2

Mathematical Modelling / Computer Modelling Specialization

No.	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 203/4	:	Vector Calculus	MAT 102 (S)	1
9.	MAT 222/4	:	Differential Equations II	MAT 122 (S)	1
10.	MAT 282/4	:	Engineering Computation I	MAT 181 (S)	1
11.	MSG 228/4	:	Introduction to Modelling	MAT 122 (S)	2
12.	MSG 281/2	:	Modelling Laboratory I	MAT 181 (S)	1
13.	MSG 282/2	:	Modelling Laboratory II	MSG 281 (S)	2
14.	MSG 284/4	:	Introduction to Geometric Modelling	MAT 181 (S) and MAT 102 (S)	2
15.	MSG 322/4	:	Fluid Mechanics	MAT 222 (S)	2
16.	MSG 327/4	:	Mathematical Modelling	MSG 228 (S)	1
17.	MSG 383/4	:	Data Structures for Computer Graphics	MAT 181 (S)	2
18.	MSG 387/4	:	Computer Graphics	MAT 181 (S)	1
19.	MSG 388/4	:	Mathematical Algorithms for Computer Graphics	MSG 284 (S)	1
20.	MSG 389/4	:	Engineering Computation II	MAT 282 (S)	2
21.	MSG 391/6	:	Project	Mathematical Modelling : MSG 228 (S) Computer Modelling : MSG 284 (S)	1 and 2

The offering and prerequisites of courses for the mathematics component of **Mathematics and Economics specialization** are the same as for those in Applied

Statistics / Operations Research specialization. The prerequisites of courses for the Economics component are as follows:

No.	Code & Title of Courses			Prerequisite
1.	SKW 104/4	:	Introduction to Economic Issues	-
2.	SEW 211/4	:	Microeconomics I	SKW 104 (P)
3.	SEW 212/4	:	Microeconomics II	SEW 211 (S)
4.	SEW 213/4	:	Macroeconomics I	SKW 104 (P)
5.	SEW 214/4	:	Macroeconomics II	SEW 213 (S)
6.	SEP 221/4	:	Applied Statistics and Econometrics	SKW 104 (P)
7.	SEU 225/4	:	Development Economics	SKW 104 (P)
8.	SEU 226/4	:	Labour Economics	SKW 104 (P)
9.	SEU 228/4	:	Malaysian Economy	SKW 104 (S)
10.	SEU 229/4	:	Islamic Economics	SKW 104 (P)
11.	SEU 322E/4	:	Applied Economics	SEW 212 (S) and SEW 214 (S)
12.	SEU 323E/4	:	Monetary Economics	SEW 213 (S)
14.	SEU 327E/4	:	Agricultural Marketing Economics and Cooperative	SKW 104 (P)
15.	SEU 329E/4	:	Public Sector Economics	SEW 212 (S)
16.	SEU 330E/4	:	International Trade	SEW 211 (S)
17.	SEU 331E/4	:	International Finance	SEW 213 (S)

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.

Passing prerequisite (P) means if course A is a passing prerequisite (P) to course B, then course A must be taken and a minimum grade of C has been obtained in course A before course B is taken.

SPECIALIZATION AND COMPULSORY CORE COURSES REGISTRATION GUIDE

Applied Statistics Specialization

Year of Study	Semester 1	Units	Semester 2	Units
1	MAT 101 MAT 161 MAT 181	4 4 4	MAT 111 MAT 102 MSG 162	4 4 4
2	MAT 251 MAT 263 MSG 285	4 4 2	MAT 122 MSG 262* MSG 265* MSG 286	4 4 4 2
3	MAT 363 MSG 366* MSG 391	4 4 6	MSG 367* MSG 368* MSG 391	4 4 6

* Optional Courses : Choose 4 from the 5 listed courses.

Operations Research Specialization

Year of Study	Semester 1	Units	Semester 2	Units
1	MAT 101 MAT 161 MAT 181	4 4 4	MAT 111 MAT 102 MSG 162	4 4 4
2	MAT 251 MAT 263 MSG 285	4 4 2	MAT 122 MSG 252* MSG 253* MSG 286	4 4 4 2
3	MAT 363 MSG 354* MSG 391	4 4 6	MSG 355* MSG 356* MSG 391	4 4 6

* Optional Courses : Choose 4 from the 5 listed courses.

Computer Modelling Specialization

Year of Study	Semester 1	Units	Semester 2	Units

1	MAT 101 MAT 111 MAT 181	4 4 4	MAT 161 MAT 102 MAT 122	4 4 4
2	MAT 203 MAT 222 MAT 282 MSG 281	4 4 4 2	MAT 202 MSG 282 MSG 284	4 2 4
3	MSG 387 MSG 388 MSG 391	4 4 6	MSG 383 MSG 391	4 6

Mathematical Modelling Specialization

Year of Study	Semester 1	Units	Semester 2	Units
1	MAT 101 MAT 111 MAT 181	4 4 4	MAT 161 MAT 102 MAT 122	4 4 4
2	MAT 222 MAT 282 MSG 281	4 4 2	MSG 228 MSG 282 MSG 389	4 2 4
3	MAT 203 MSG 327 MSG 391	4 4 6	MAT 202 MSG 322 MSG 391	4 4 6

Mathematics and Economics Specialization

Students are required to check the list of courses offered at the beginning of each academic session.

Year of Study	Semester 1	Units	Semester 2	Units
1	MAT 101 MAT 161 SKW 104	4 4 4	MAT 111 MAT 102 MSG 162 SEU 225[b] SEU 228[b]	4 4 4 4 4
2	MAT 251 MAT 263 MSG 285 SEW 211 SEW 213	4 4 2 4 4	MAT 122 MSG 286 SEW 212 SEW 214	4 2 4 4
3	MAT 363 MSG 391 SEP 221 SEU 229[b] SEU 226[b] SEU 323[c] E SEU 329[c] E SEU 330[c] E	4 6 4 4 4 4 4 4	MSG 356[a] MSG 367[a] MSG 391 SEU 322[c] E SEU 327[c] E SEU 331[c] E	4 4 6 4 4 4

Optional Courses - [a] Choose 1 from these courses.
- [b] Choose 1 from these courses.
- [c] Choose 3 from these courses.

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.

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 each academically excellent student who has 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 both academically and in 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

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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, integratibility, 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 diff vghb erentiation 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 method 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 method 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. Berrosford, 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.
Eigen values, eigen vectors, 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:
Eigen values and eigen vectors, 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 develope a firm understanding of the solutions structure of linear systems
2. describe the key concepts of Euclidean vector space $\mathbb{R}^n$ and linear transformations on $\mathbb{R}^n$
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 distribution: 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, McNemar 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 determini 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 apply 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 modeling
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. 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 stuctures. 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.

11. 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.
Nonparametric 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.

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 view point
4. construct mathematical proof 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 artesian, 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. 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,

onditional expectation, independence of two random variables, bivariate normal random variables.
Transformation 1-1. 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 kth. 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*, 5^{th} edition. Prectice Hall.
2. Hogg, R.V. and Tanis, E.A. (2001). *Probability and Statistical Inference,* 6^{th} edition. Prectice Hall.
3. Ross, S. (2006). *A First Course in Probability*, 7^{th} edition. Pearson Prentice Hall.

17. 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 eigen vectors.

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.

18. 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.

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 taught 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. MSG 253/4 Queueing System and Simulation

Queuing theory: general queueing model, terminologies and notations. Characteristics of exponential and Poisson distributions. Birth and death process. Discussion about the theoretical and also the application of queueing models: M/M/1 and its extension.
Queueing models involving nonexponential distributions.
Queueing networks.
Simulation: general simulation concept. Random numbers. Discrete event simulation.
Applications of software packages for modelling and simulation of queueing systems.

Course Outcomes
Upon completion of this course, students are able to
1. derive the performance measurement formulas of various queueing models
2. assess queueing systems using analytical methods and simulation
3. master the use of a computer simulation package
4. strengthen their mathematical and professional report writing ability.

Reference Books
1. Gross, D. & Harris, C.M. (1998) *Fundamentals of Queuing Theory,* 3rd edition. John Wiley& Sons.
2. Chisman, J.A. (1992) *Introduction to Simulation Using GPSS/PC.* Prentice Hall.
3. Taha H.A. (2003) *Operation Research: An Introduction,* 7th edition. Prentice Hall.

22. 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 $\bar{X}-R, \bar{X}-S$, 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

23. MSG 265/4 Design and Analysis of Experiments

Introduction to factorial designs: the general factorial design; two-factor and three-factor factorial designs, statistical analysis of the fixed effects model and the random effects model, model adequacy checking, fitting response curves, blocking in a factorial design.
The 2^k Design: 2^2 design and 2^3 design, a single replicate of the 2^k design.
Blocking and confounding in the 2^k factorial design: blocking a replicated 2^k factorial design, confounding in the 2^k factorial design, confounding the 2^k factorial design in two blocks, confounding the 2^k factorial design in four blocks, confounding the 2^k factorial design in 2^p blocks, partial confounding.
Two-level fractional factorial designs: the one-half fraction of the 2^k design; definitions and basic principles, design resolution and construction and analysis of the one-half fraction, the one-quarter fraction of the 2^k design and the general 2^{k-p} fractional factorial design.
Three-level and mixed-level factorial design.
Nested and split-plot designs: the two-stage nested design and the general m-stage nested design, design with both nested and factorial factors, the split-plot design; split-plot designs with more than two factors and the split-split-plot design.
Taguchi approach.
Response surface methods.
The analysis of covariance.

Course Outcomes
Upon completion of this course, students are able to
1. identify the different design of experiments and explain the procedures of designing those experiments
2. perform the analysis of variance for the data obtained from different designs
3. interprete the results and write the conclusions for the different designs.

Reference Books
1. Montgomery, D.C. (2005). *Design and Analysis of Experiments,* 6th edition. John Wiley & Sons, Inc.
2. Berger, P.D. and Maurer, R.E. (2002). *Experimental Design with Applications in Management,* Engineering and the Sciences. Duxbury
3. Snedecor, G.W. and Cochran, W.G. (1967). *Statistical Methods,* The Iowa State University Press, Ames, Iowa.

24. MSG 281/2 Modelling Laboratory I

Computer Modeling : use of CAD/CAM packages.
Mathematical Modeling : basic scientific computation using MATLAB.

Course Outcomes
Computer Modelling:
Upon completion of this course, students are able to
1. use CAD/CAM packages to transfer hand-created drawings into the computer using primitive drawing objects
2. assemble and edit given drawing objects
3. draw curves and solids using 3-D features and use a shading technique to render the models.

Mathematical Modeling :
Upon completion of this course, students are able to
1. use mathematical software tools with competence
2. find information needed to solve a computerized problem
3. analyze a problem and determine if it could feasibly be solved with current resources, design a solution and implement the solution.

Reference Books
1. Kedah - ISR Technology Sdn. Bhd. (1995) *Reference Manual KIT-Modeller.*
2. Noor Atinah Ahmad, Yahya Abu Hasan, Zarita Zainuddin & Low Heng Chin (2002). *MATLAB: Pendekatan Penyelesaian Masalah Matematik.* Mc Graw Hill.

25. MSG 282/2 Modelling Laboratory II

Computer Modelling: use of packages for graphical animation. Introduction to the use of *Mathematica* in computer graphics.
Mathematical Modelling: basics understanding of the structure and syntax of *Mathematica* program. Numeric, symbolic and graphical computations using *Mathematica* built-in functions. Introduction to *Mathematica* programming styles that include procedural, rule-based and functional programming. Problem solving in calculus, differential equations, simple mathematical modelling and data analysis and visualization.

Course Outcomes
Computer Modelling :
Upon completion of this course, students are able to
1. use graphics packages to solve computer aided geometric design problems
2. develop 2-D and 3-D models in a computer
3. produce an animation video clip with low end hardware and software.

Mathematical Modelling:
Upon completion of this course, students are able to
1. understand the general structures and syntax of Mathematica

2. use Mathematica to perform numerical computations, symbolic computations (manipulating formulas) and graphical manipulations (create 2-D and 3-D graphs)
3. write simple Mathematica programs in procedural, rule-based and functional-based styles to perform desirable tasks
4. use Mathematica as a tool in solving simple mathematical models
5. create and document computational models for mathematical experiments and explorations.

Reference Books

1. Murdock, K.L. (2005) *3Ds Max 7,* Wiley Publishing, Inc.
2. Giambrano, (1997). *"3D Graphics and Animation: From star up to standing out",* New Riders Publishing.
3. Paul R. Wellin (2005) *An Introduction to Programming with Mathematica,* 3rd edition. Cambridge University Press.
4. Stephen Wolfram (2003).*The Mathematica Book,* 5th edition Wolfram Media.
5. Springer-Verlag (2005). *The Mathematica Guide Books, Vol I- IV,* New York.

26. MSG 284/4 Introduction to Geometric Modelling

What is geometric modeling: mathematical methods in geometric modeling. Some historical background. Data fitting and parametric interpolation. Geometric smoothness versus parametric smoothness. Representation by parametric and implicit equations.
Introduction to differential geometry: tangent, normal, binormal, curvature, torsion, Frenet-Serret formulas, osculating circle, first fundamental and second fundamental forms, Meusnier theorem, mean and Gaussian curvatures.
Polynomial interpolation: Lagrange polynomial, Hermite polynomial, Aitken algorithm.
Bernstein polynomial: motivation, partition of unity, positivity, symmetry, recursive property and derivatives.
Bézier curves and surfaces: derivatives, de Casteljau algorithm, shape preserving properties, degree reduction and elevation, tensor-product.
B-splines curves and surfaces: B-splines basis, properties of B-splines curves, B-spline surfaces, relation with Bézier.
Parametric and geometric continuity: definition, differences between parametric and geometric continuity, application of these continuity to composite curves and surfaces.
Coons surfaces: Boolean sum, compatibility conditions.

Course Outcomes

Upon completion of this course, students are able to
1. have the knowledge of geometric modelling and able to practice them confidently
2. analyze and interpret the geometric properties of curves and surfaces in mathematical representations
3. build and manipulate curves and surfaces using computers.

Reference Books
1. Faux and Pratt (1980), *Computational Geometry for Design and Manufacture*, Chichester, England: Halsted Press.
2. Mortenson (1997), *Geometric Modelling*, Wiley.
3. David Salamon (1999), *Computer Graphics and Geometric Modeling*, Springer Verlag.

27. MSG 285/2 Statistical Laboratory

Expose students on the applications of certain statistical packages such as SPSS, SAS, Minitab, Statgraphics to analyse data and interpret their results.

Course Outcomes
Upon completion of this course, students are able to
1. apply statistical packages to the data set
2. relate the statistical reasoning from the results obtained
3. interpret results in simple case study.

Reference Books
1. Montgomery, D.C. (2000). *Designand Analysis of Experiment*, Wiley.
2. Conover, W.J. (1999). *"Practical Nonparametric Statistics"*. John Wiley.
3. Christensen, R. (1996). *"Analysis of Variance, Design and Regression"*, Chapman & Hall.

28. MSG 286/2 Operations Research Laboratory

Use of operations research packages such as SAS/OR, TORA, LINDO, LINGO, QM/POM, Microsoft Project and others will be taught. Applications to real world problem will be emphasised.

Course Outcomes
Upon completion of this course, students are able to
1. formulate and interpret outputs of the linear programming problems solved by the specified softwares
2. use the OR softwares taught to solve LP problems
3. relate to and learn any future OR softwares using the help files and tutorials.

Reference Books
1. Linus Schrage (1997). *Optimization Modeling with LINDO* 5th edition. Brooks/Cole Publishing Company.
2. Elaine Marmel (1999). *Microsoft Project 2000 Bible*, IDG Books Worldwide.
3. Taha, H.A. (2003). *Operations Research: An Introduction.* 7th edition. Prentice Hall.

29. 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.W. *Fluid Mechanics* 5th edition. McGraw Hill.

30. MSG 327/4 Mathematical Modelling

The objective of this course is to enable students to see how mathematical models are developed from first principles and then to see the consequences through further mathematical and numerical analysis.
Models (which should be amenable to analysis) from a particular area of applied mathematics are taken to illustrate the ideas.
References will be provided by the instructor of the course.

Course Outcomes
Upon completion of this course, students are able to
1. formulate and solve simple real life problems by ODE by analytical and numerical methods such as RK2 and RK4
2. formulate and solve real life problem simulations by PDE using analytical and numerical solution techniques such as FDM and FSM
3. design and implement efficient codes by FORTRAN, MATLAB and MATHEMATICA to solve real life problem simulations
4. interpret and synthesize simulation results by means of WASP7 and in-house simulation models I1Disp, E2DISP, TUNA, DEER.

31. MSG 354/4 Network Flows

Basic concepts of graphs and network

Minimum spanning tree problem: Kruskal algorithm, Prim algorithm and applications.
Shortest route problem: tree building program, tree changing algorithm, Floyd algorithm, Yen algorithm and applications.
Maximum flow problem: cut-set concept, Ford-Fulkerson labelling algorithm and applications.
Minimum cost flow problem: Busacker & Gowen algorithm, Klein algorithm, General network simplex method, 'Out-of-Kilter' algorithm and applications.
Chinese postman problem: Eulerian circuit and some solutions methods.
Travelling salesman problem: Hamiltonian circuit and some branch and bound solution techniques.

Course Outcomes
Upon completion of this course, students are able to
1. formulate/translate real life problems as network flow problems
2. comprehend the underlying theorems of network flow problems
3. use appropriate algorithms to solve network flow problems
4. perform economic interpretation of network flow solutions.

Reference Books

1. Ahuja, R.K, Magnanti,T.L & Orlin, J.B . *Network Flows: Theory, Algorithmn and Application.* Prentice Hall.
2. Adli Mustafa (1991). *Aliran Rangkaian,* Pulau Pinang: Penerbit USM.
3. Taha, H.A. (2003). *Operation Research: An Introduction,* 7th edition. New Jersey : Prentice Hall.

32. MSG 355/4 Inventory Control

Basic concepts of inventory control. ABC inventory system. General inventory control model.
Deterministic inventory models: classic EOQ model, buffer stock, price breaks model, N-period production scheduling model, N-period dynamic EOQ model, multiple-item with storage limitation model.
Probabilistic models: continuous review model single period model, multiperiod model.

MRP, JIT system. Use of computer packages to obtain solutions.

Course Outcomes
Upon completion of this course, students are able to
1. explain clearly the basic issues in inventory management
2. identify a suitable model for a given inventory problem
3. use a suitable method for finding the optimum solution to a given inventory problem
4. interprete the solution obtained from a given inventory problem.

Reference Books

1. Johnson, L. and D. Montgomery (1974). *Operations Research in Production, Planning, Scheduling and Inventory Control.* New York: Wiley.
2. Love, S. (1979). *Inventory Control,* New York: MacGraw-Hill.
3. Taha, H.A. (2003). *Operations Research: An Introduction.* New Jersey : Prentice Hall.

33. MSG 356/4 Mathematical Programming

Introduction: review of differential calculus, basic concepts in optimisation theory, including extremum (maximum and minimum), optimality criteria and convexity.
Nonlinear 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.

34. MSG 366/4 Multivariate Analysis

Introduction. Multivariate data. Applications of multivariate techniques.
Revision of matrix algebra and random vectors. Quadratic forms. Sample geometry. Random sampling.
Multivariate normal distribution. Sampling distributions for $\overline{X}$ and $\overline{S}$. Inference for the mean vector. Confidence region and simultaneous comparison of the component means.

Comparison of several multivariate means. MANOVA.
Introduction to principal component analysis. Population and sample principal components. Applications.
Introduction to factor analysis. Orthogonal factor model. Methods of estimation. Factor rotation and factor scores. Applications.
Introduction to discrimination and classification. Discrimination techniques. Classification for two multivariate normal populations. Fisher's discriminant Function. classification for several populations. Applications.
Introduction to clustering methods. Similarity measures. Hierarchical clustering methods: single linkage, average linkage and complete linkage. Nonhierarchical clustering methods: Mac Queen's K-mean methods. Applications.

Course Outcomes
Upon completion of this course, students are able to
1. define and describe the ideas of multivariate data and techniques
2. apply both graphics and quantitative multivariate techniques to data analysis
3. analyze, interpret and solve multivariate problems
4. work as a team to solve multivariate problems
5. communicate orally and in written form pertaining to multivariate analysis.

Reference Books

1. Johnson, R.A. & Wichern, D.W. (2002). *Applied Multivariate Statistical Analysis,* 5th edition. Prentice Hall International, New Jersey.
2. Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. (1998). *Multivariate Data Analysis,* 5th edition. Prentice Hall International, New Jersey.
3. Manly, B.F.J. (1994). *Multivariate Statistical Methods: A primer,* 2nd edition. Chapman & Hall, New York, USA.

35. MSG 367/4 Time Series

Introduction: examples of time series data, stationary time series, transformation (filtering and differencing). Autocorrelation functions and partial autocorrelation functions.
Probability models for time series: pure random process (white noise), random walk, moving average process (MA process), autoregressive process (AR process), mixed model (ARMA process), integrated models (ARIMA process).
Estimation in the time domain, forecasting: Box-Jenkins methods.
Frequency approach to time series. Spectral analysis.
Case studies will be given.

Course Outcomes
Upon completion of this course, students are able to
1. fully understand and explain the fundamental time series concepts and terminologies
2. select appropriate models for the given time series

3. critically differentiate time series elements such as non-stationary, seasonal and heteroscedasticity
4. apply a group of time series models to any time series data using various time series statistical packages such as Minitab, SPSS and EViews
5. produce a well-organized report which includes concise explanation of the steps taken and interpreting results of time series analysis.

Reference Books

1. William W. S. Wei *Univariate and Multivariate Methods.*
2. John Gottman *A Comprehensive Introduction for Social Scientists,* Cambridge University Press.
3. Chatfield, C. (1996). *The Analysis of Time Series: An Introduction,* hapman & Hall.

36. MSG 368/4 Sample Survey and Sampling Technique

Sampling design: simple random sampling design for finite population – with and without replacement, stratified sampling design, cluster sampling design, systematic sampling design, two-stage sampling design. Regression and ratio estimates. Estimation and bound estimation error.
Sample size determination for the above sampling designs.

Course Outcomes

Upon completion of this course, students are able to

1. identify the design of sample survey
2. apply the sampling procedures for selecting the sample from the population
3. differentiate methods for estimating population parameters and the bounds on the error of estimations
4. generate inferences about a population from the information contained in a sample.

Reference Books

1. Scheaffer, L.R, Mendenhall, W. and Ott, R.L. (1995) *Elementary Survey Sampling,* Duxbury Advanced Series.
2. Cochran, W.G. (1977). *Sampling Techiques*, John Wiley. Sons.
3. Thompson, M.E. (1997). *Theory of Sample Surveys,* Chapman & Hall,

37. MSG 383/4 Data Structures for Computer Graphics

Introduction to information and data. One's and two's complements. Ways to store data in different data types, for example as integers, real numbers and characters.
Computer memory management. Static and dynamic memory allocations. Advantages and problems of each allocation.
Introduction to linear data structures, for example, linked list; and non-linear data structures, for example, binary trees, binary search trees, quadtrees, octtrees and BSP trees. Representation of the data structures by using both arrays and linked lists.

Recursion: definitions and processes. Behaviours of recursion and its program implementation.
Sorting: background in general. Bubble sort, selection sort, quick sort, binary tree sort and radix sort.
Searching: algorithms and analysis of searching; sequential search, binary search and binary tree search.
Fractal geometry: descriptions of self-similarities and fractal dimensions by using Sierpinski triangle and von Koch snow flakes. Comparison of fractals and L-grammars.
Introduction to graphics file format. Differences between bitmap graphics and vector graphics. Graphics file compression techniques by using run-length encoding and Huffman codings. Descriptions of commonly used graphics file formats, for example, CGM, DXF, BMP, JPG, GIF and PNG.

Course Outcomes
Upon completion of this course, students are able to
1. have the knowledge on the fundamental concepts and computational algorithms of data structures for computer graphics
2. implement the computational algorithms and techniques of data structures with a high level of confidence and proficiency
3. design, manipulate, combine and compare different types of data structures used in computer graphics.

Reference Books

1. James D. Foley et al. (1993). *Introduction to Computer Graphics,* Addison-wesley Publishing Company.
2. Donald Hearn and M. Pauline Baker (1986). *Computer Graphics C. Version,* 2nd edition. Prentice-Hall.
3. Malik,D.S. *Data Structures Using C++,* (2003). Thomson Course Technology.

38. MSG 387/4 Computer Graphics

Introduction to computer graphics and its applications. Overview of raster graphics and transformation pipeline, i.e. transformations between different coordinate systems, which involve modelling coordinate system, device coordinate system, world coordinate system, normalized coordinate system, display window coordinate system and screen coordinate system.
Graphics output primitives in drawing of lines, polygons, triangles, etc. Draw polylines with different line joining methods. Attributes of graphics primitives like colour, line style and fill style. Difference between RGB colour code and colour lookup tables. Constructing pixel mask for line styles and using bit arrays for fill style.
2D and 3D transformations and viewing. Describing and using viewing parameters to change the shape of the object, using viewport to change the ratio of clipping window. Differences in viewing and modelling transformations. Window clipping by Cohen-Sutherland algorithm.
Explanation on software standards and GKS, logical input devices defined under GKS. Various interactive picture construction techniques, e.g. basic

positioning methods, dragging, constraints, grids, rubber-band methods and gravity field.
Raster methods for computer animation, i.e. double buffering and raster operations. The effect caused by difference in refresh cycle of raster monitors and object construction time taken by the buffer. Design of animation sequence in 4 development stages, i.e. storyboard layout, object definitions, key-frame specifications, generations of in-between frames.
OpenGL functions are used throughout the syllabus to illustrate the computer graphics concepts.

Course Outcomes
Upon completion of this course, students are able to
1. understand the fundamental concepts and standards in computer graphics
2. use graphics pipeline and appropriate transformations involved at each stage of the pipeline
3. apply the right techniques in producing pictures through programming
4. produce 2-D animations.

Reference Books

1. Donald Hearn, M. Pauline Baker (2003). *Computer Graphics with OpenGL,* 3rd edition. Prentice Hall.
2. James, D. Foley et al. (1993). I*ntroduction to Computer Graphics,* Addison-wesley Publishing Company.
3. Richard, S. Wright, Benjamin Lipchak. *OpenGL SuperBible,* 3rd edition. Sams Publishing Company.

39. MSG 388/4 Mathematical Algorithms for Computer Graphics

Bézier curves and surfaces:
Degree elevation and subdivision algorithm, reparameterization, composite curves and surfaces, rational curves and surfaces. Triangular Bézier surfaces.
Splines:
Splines and natural splines. Basis functions using truncated power functions and properties.
B-spline curves and surfaces:
Basis functions using convolution method, de Boor Cox algorithm. Uniform and non-uniform basis functions, subdivision algorithm, knot insertion algorithm, relation between the number of control points and knots, conversion between basis functions, NURBS, beta splines and corner-cutting algorithm, subdivision algorithm for irregular surfaces (Catmull-Clark).

Course Outcomes
Upon completion of this course, students are able to
1. have a firm understanding of the mathematical algorithms in computer graphics, and the principles and theories of computer modelling
2. use mathematical and computational methods to describe and design curves and surfaces
3. simulate and represent an object geometrically under a computer control.

Reference Books

1. Faux and Pratt (1980). C*omputational Geometry for Design and Manufacture,* Chichester, England: Halsted Press.
2. Mortenson (1997). *Geometric Modelling,* Wiley.
3. David Salamon (1999). *Computer Graphics and Geometric Modeling*, Springer-Verlag.

40. MSG 389/4 Engineering Computation 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.

41. MSG 391/6 Project

The aims of this course are

(i) to give an opportunity for students to work on a particular topic relevant to the program
(ii) to give students an introduction to the methods and experience of research and to make them better prepared to start a research degree or work in a research and development environment
(iii) to develop students' ability to organize their work in a substantial project

(iv) to develop students' ability to present their work in both written and oral form.

Course Outcomes

Upon completion of this course, students are able to

1. carry out a research project
2. conduct a meaningful discussion on the various aspects related to the project
3. write a report and present their research findings.