Subject: Applied Mathematics (AMAT)

B.Sc.

	Course Units	Status	Pre-requisite	Co-requisite
Year 1 Sem 1	AMAT 11513 Vector Analysis	C	A/L Combined Mathematics	
	AMAT 11522 Mechanics I	C	A/L Combined Mathematics	
Year 1 Sem 2	AMAT 12532 Vector Methods in Geometry	C	AMAT 11513	
	AMAT 12543 Numerical Methods I	C	AMAT 11513	
Year 2 Sem 1	AMAT 21552 Scientific Computing using Appropriate Software I	C	AMAT 12543	
	AMAT 21562 Mechanics II	C	AMAT 11522	
Year 2 Sem 2	AMAT 22572 Numerical Methods II	C	AMAT 12543	
	AMAT 22582 Scientific Computing using Appropriate Software II	C	AMAT 21552	AMAT 22572
Year 3 Sem 1	AMAT 31603 Mathematics for Finance I	O	PMAT 11522	
	PRPL 31992 Professional Placement	O	All AMAT course units offered in Level 1 & 2	
	AMAT 31613 Computational Mathematics	C	AMAT 22582	
Year 3 Sem 2	AMAT 32593 Mathematical Modelling	C	PMAT 22572	
	AMAT 32623 Introduction to Fluid Dynamics	O	PMAT 22583	
	AMAT 32633 Mathematics for Finance II	O	AMAT 31603	
	AMAT 32643 Mechanics III	O	AMAT 21562	

B.Sc. (Hons)

	Course Units	Status	Pre-requisite	Co-requisite
Year 3 Sem 1	AMAT 41763 Qualitative and Quantitative Behaviour of the Solutions of Ordinary Differential Equations	C	PMAT 22572	
	AMAT 41773 Advanced Computational Mathematics	C	AMAT 22582	
Year 3 Sem 2	AMAT 42783 Advanced Mathematical Modelling	C	AMAT 41763	
	AMAT 42793 Fluid Dynamics	C	PMAT 41763	
	AMAT 42803 Graph Theory	O	PMAT 21553	
Year 4 Sem 1	AMAT 41813 Financial Mathematics	O	PMAT 11522	
	AMAT 41823 Quantum Mechanics	C	AMAT 11513	
	AMAT 43976 Research/Study Project[1]	C		
	AMAT 41833 Linear and Nonlinear Programming	C	PMAT 21553	
Year 4 Sem 2	AMAT 42843 Quantum Field Theory	O	AMAT 41823	
	AMAT 42853Tensors and General Relativity	O	PMAT 21553	

[1]

Compulsory for the students who have not offered PMAT 43976

Applied Mathematics

Level – 1

**Course Code : ** AMAT 11513
**Title : ** Vector analysis
**Pre-requisites : ** A/L Combined Mathematics

Learning Outcomes:
At the end of the course the student will be able to
1. establish the theorems of Vector Algebra
2. define the concepts and theorems of Vector analysis
3. apply them in classical field theories in Physics.

Course Content :
Vector Algebra: Introduction to vectors, Condition for coplanarity of three vectors, Orthogonal triads of unit vectors, Scalar and vector products, Triple products, Solution of vector equations.
Vector Analysis: Scalar and vector fields, Differentiation of vector functions, Surfaces and normals, Gradient, Divergence and Curl operators and identities involving them, Divergence and Stokes' theorems, Conservative and solenoidal fields.

Method of Teaching and Learning: A combination of lectures and tutorial discussions.

Assessment : Based on tutorials, tests and end of course examination.

Recommended Reading :

1. Spiegel, M. & S. Lipschutz. *Vector Analysis*, (2e) McGraw-Hill Education, 2009.
2. Chatterjee, D. *Vector Analysis,* PHI Learning private limited, India, 2009.
3. Davis, H.F. & Snider, A.D. *An Introduction to Vector Analysis*, C. Brown, New York, 1992.

**Course Code : ** AMAT 11522
**Title : ** Mechanics I
**Pre-requisites : ** A/L Combined Mathematics

Learning Outcomes:
Upon successful completion of this course, the student should be able to
1. collect and organize a sound knowledge of basic concepts of Kinematics and Newtonian dynamics
2. apply Newton's laws in solving problems related to the motion of a particle.

Course Content:
Newtonian Kinematics: Inertial frames, Transformations between inertial frames, Relative motion of particles, Relative motion of frames of reference.
Motion of a Particle: Mass, Momentum, Torque and angular momentum, Equation of motion in vectorial form, One dimensional motion, Integrals of motion, Work, kinetic energy & potential

energy, Impulse, Motion under a conservative forces, Motion under a central force, Kepler's laws, Rotating frames of reference, Motion relative to rotating earth.

System of Particles: Centre of mass, External and internal forces, Integrals of motion, Momentum, Angular momentum, Work, kinetic energy & potential energy, Conservative systems, Constants of motion.

Method of Teaching and Learning : A combination of lectures and tutorial discussions.

Assessment: Based on tutorials, tests and end of course examination.

Recommended Reading:

1. Greiner, W. *Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, second edition*, Springer, 2010
2. B.H. Chirgwin, C. Plumpton. *Advanced Theoretical Mechanics: A Course of Mathematics for Engineers and Scientists, Volume 6*. Elsevier, 2013
3. D. Strauch, *Classical Mechanics, An Introduction*, Springer, 2009
4. Rao, K.S. *Classical Mechanics*, Universities Press, 2003
5. Chorlton, F. *Text book of Dynamics*, D. Van Nostrand, 1969.
6. Desloge, E.A. *Classical Mechanics*, John Wiley, New York, 1982.
7. Anil V. Rao, *Dynamics of Particles and Rigid Bodies: A Systematic approach*, Cambridge University Press. 2006.
8. Dieter Strauch, *Classical Mechanics, An Introduction*, Springer, 2009

Course Code : AMAT 12532
Title : Vector Methods in Geometry
Pre-requisites : AMAT 11513

Learning Outcomes:
At the end of the course the student will be able to apply the knowledge in vectors to Geometry.

Course Content :
Lines and planes: Vector form of lines and planes, Parameterized Curves.

Curves and Surfaces: Vector form of Planes, Frenet-Serret formulae.

Curvilinear Coordinates : Differential Operators, Surface Elements and Volume Elements in Curvilinear Coordinates, Spherical, Cylindrical Coordinate Systems.

Theory of Surfaces: Concept of a surface, Implicit Equation of a Surface, Parametric Equation, Parametric Curves, Curves on a Surface, Tangent Plane, Normal Vector, Surface of Revolution.

Method of Teaching and Learning: A combination of lectures and tutorial discussions.

Assessment : Based on tutorials, tests and end of course examination.

Recommended Reading :

1. Shanthi Narayan, Vector Algebra, S. Chands and Company, 2005

2. L, Brand. *Vector Analysis*. Courier Corporation, 2012
3. L.R. Shorter. *Problems and Worked Solutions in Vector Analysis*. Courier Corporation, 2014

****

Course Code : AMAT 12543
Title : Numerical Methods I
Pre-requisites : AMAT 11513

Learning Outcomes:
At the end of the course, the student should be able;
1. to implement numerical methods for a variety of multidisciplinary applications
2. to establish the limitations, advantages and disadvantages of numerical methods
3. to develop and use algorithms and theorems to find numerical solutions and bounds on their error to various types of problems including root finding, polynomial approximation, curve fitting, solution of system of equations.

Course Contents:
Introduction: Floating point number system, Error in numerical computation, Strategies for minimizing round-off errors, Ill Conditioning, Condition Number, Notion of algorithm.
Solution of equations with one variable: Numerical solution of nonlinear equations using Bisection method, False Position method, Fixed-Point iteration method, Newton-Raphson method and Secant method, modified secant method, Error Analysis for Iterative methods, Accelerating Convergence and Aitken's method**,** Solutions of polynomial equations and Horner's method.
Difference Operators: Forward, Backward, Central, Averaging operators, Symbolic Relations of Difference operators, Difference Table and Error Propagation, Difference Equations, Factorial Polynomials.
Interpolation: Collocation Polynomial and its properties, Newton's Forward and Backward Difference Formulae, Gauss's Central Difference Formula, Interpolation with unevenly spaced points; Lagrange's, Newton's and, Spline Interpolation; Linear, Quadratic and Cubic Spline Interpolation.
Approximation of functions: Least square curve fitting for linear and non-linear functions.
Solution of System of Linear Equations (Direct Methods): Matrix inversion, Naïve Gauss Elimination ,Gaussian eliminations with partial pivoting, Ill conditioning Matrices, Operation counts, Matrix Decomposition Techniques; LU and QR Factorizations
of Teaching and Learning: A combination of lectures and tutorial discussions

Assessment: Based on tutorials, tests and end of course examination

Recommended Reading :
1. Burden, R.L., Faires, J.D, Burden, A.M. *Numerical Analysis (10e)*, Cengage Learning. (2015).
2. Sastry, S. S., *Introductory Methods of* Numerical *Analysis (5e)*, Prentice Hall India. (2012).
3. Kreyszig, E., *Advanced Engineering Mathematics (10e)*, John Wiley. (2010).
4. Gerald, C.F, *Applied Numerical Analysis (7e)*, Pearson India. (2004).

****

LEVEL II

**Course Code : ** AMAT 21552
**Title : ** Scientific Computing using appropriate software I
**Pre-requisites : ** AMAT 12543

Learning Outcomes:
On completion of this unit, the student should be able to write computer programs to solve structured engineering and mathematical problems using appropriate numerical techniques in software environment.

Course Contents:
Introduction to software: software as a calculator, Basic Mathematical functions, Vectors, Accessing elements of arrays and array manipulation, Scripts and function files, plotting simple functions
Programming: Loops and conditional statements, specific commands, error checking and displaying.
Applications: Roots of nonlinear equations using and Graphical Methods, Bisection Method, False Position Method, Fixed-point Method, Newton Raphson Method, Secant Method.

Method of Teaching and Learning: A combination of lectures and computer laboratory sessions.

Assessment: Based on tutorials, tests and end of course examination.

Recommended Reading :

1. S.C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, McGraw-Hill, (2017).
2. Jaan Kiusalaas, *Numerical Methods in Engineering with MATLAB (3e)*, Cambridge University Press, 2015
3. S.R. Otto and J.P. Denier, *An Introduction to Programming and Numerical Methods in MATLAB,* Springer-Verlag London Limited 2005

****

**Course Code : ** AMAT 21562
**Title : ** Mechanics II
**Pre-requisites : ** AMAT 11522

Learning Outcomes :
Upon successful completion of this course, the student should be able to
1. apply Newton's laws in solving simple problems related to the motion of a particle a system of particles and rigid bodies
2. collect and organize a sound knowledge of Lagrangian approach to mechanics.

Course Content :
Rigid Body Motion: Rigid bodies, Moments and products of inertia, Principal axes, Equimomental systems, Motion of a lamina, Instantaneous centre, Body and space centrodes, Uniplanar motion of a rigid body, Impulsive motion, Euler's equations of Motion.
Lagrangian Mechanics: Generalized coordinates, Lagrange's equations of motion for elementary systems, Constraint forces, Lagrange's equation of motion for holonomic systems, Determination

of holonomic constraint forces, generalized force functions, Lagrange equations, Constants of motion in the Lagrangian formalism.

Method of Teaching and Learning: A combination of lectures and tutorial discussions.

Assessment : Based on tutorials, tests and end of course examination.

Recommended Reading:

1. J.D. Kelley, J.J. Leventhal. *Problems in Classical and Quantum Mechanics: Extracting the Underlying Concepts.* Springer. 2016
2. C. Gignoux, B. Silvestre-Brac, *Solved Problems in Lagrangian and Hamiltonian Mechanics*, Springer Netherlands, 2014
3. Chorlton, F. *Text book of Dynamics*, D. Van Nostrand, 1969.
4. Desloge, E.A. *Classical Mechanics*, John Wiley, New York, 1982.
5. Ramsey, A.S. *Dynamics, Parts I & II*, Cambridge University Press, 1975.
6. Goldstein, H. *Classical Mechanics*, Addison Wesley, 1977.

****

Course Code : AMAT 22572
Title : Numerical Methods II
Pre-requisites : AMAT 12543

Learning Outcomes:
At the end of the course, the student should be able;

1. to find numerical solutions to system of equations using indirect methods,
2. to develop and use algorithms and theorems to find numerical solutions of ordinary differential equations, numerical differentiation and numerical integration

Course Contents:
Numerical Linear Algebra: Vector Norms, Matrix norms, General properties of vector and matrix norms.

Numerical Differentiation and Integration: Numerical Differentiation, Open and closed Newton-Cotes formulae, Trapezoidal, Simpson's 1/3 and 3/8 rules, Simpson quadratic formulae, Romberg integration method, Gaussian quadrature.

Modern Methods for Solving Linear Systems of Equations: Relative error bound, Condition number, Iterative and Relaxation Methods: Jacobi, Gauss-Siedel methods and their convergence, Richardson, SOR Iterative, Gradient Methods: Conjugate Gradient Method

Numerical Solutions of Ordinary Differential Equations: Explicit and Implicit numerical schemes, Taylor-Series Method, Picard's Method of Successive Approximations, Euler's method, Heun's method, **,** Midpoint method **,**Runge-Kutta Methods**,** Computation of error bound, Stability of methods, Predictor-Corrector methods.

Method of Teaching and Learning: A combination of lectures and tutorial discussions.

Assessment: Based on tutorials, tests, presentations and end of course examination.

Recommended Reading :

1. Burden, R.L., Faires, J.D, Burden, M.L. *Numerical Analysis (10e)*, Cengage Learning. (2015).
2. Trefethen L.N. & Bau D., *Numerical Linear Algebra*, Philadelphia, USA. (1997).
3. Golub H., Vanloan C.F., *Matrix computations*, JHU Press, 2013.

****

Course Code : AMAT 22582
Title : Scientific Computing using appropriate software II
Pre-requisites : AMAT 21552
Co-requisites : AMAT 22572

Learning Outcomes:
On completion of this unit, the student should be able to implement algorithms to solve structured engineering and mathematical problems.

Course Contents:
Optimization: One-Dimensional Optimization, Multidimensional Optimization.
Linear Systems: Solving Linear Algebraic Equations using the software, Naive Gauss Elimination, Pivoting, Gauss Elimination as LU Factorization,
Iterative Methods: Jacobi Method, Gauss-Seidel Method, Richardson Method, SOR Methods.
Curve Fitting: Linear Least-Squares Regression, Linearization of Nonlinear Relationships.
Numerical Integration: Trapezoidal and Simpson's methods.
Initial-Value Problems: Implement of Euler's , Heun's ,Midpoint and Runge Kutta Methods, ODE 45.

Method of Teaching and Learning: A combination of lectures and computer laboratory sessions.

Assessment: Based on tutorials, tests and end of course examination.

Recommended Reading

1. S.C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, McGraw-Hill, (2017).
2. Jaan Kiusalaas, *Numerical Methods in Engineering with MATLAB (3e)*, Cambridge University Press, 2015
3. S.R. Otto and J.P. Denier, *An Introduction to Programming and Numerical Methods in MATLAB*, Springer-Verlag London Limited 2005

****

LEVEL III

Course Code : AMAT 31603
Title : Mathematics for Finance I
Pre-requisites : PMAT 11522

Learning outcomes :
At the end of the course candidate will be able to
1. define and recognize the definitions of terms in Theory of Interest and general derivatives in Finance.

2. construct an investment portfolio to match present value and duration of a set of liability cash flows
3. calculate any remaining item using basic formulas for financial derivatives when sufficient partial information are given
4. evaluate the payoff and profit of basic derivative contracts

Course Contents:
Interest Theory: Time Value of Money: Simple and Compound Interest, accumulation function, future value, current value, present value, net present value, discount factor, discount rate (rate of discount), convertible monthly, nominal rate, effective rate, inflation and real rate of interest, force of interest, equation of value. **Annuities/cash flows:** Annuity-immediate, annuity due, perpetuity, payable monthly or payable continuously, level payment annuity, arithmetic increasing/decreasing annuity, geometric increasing/decreasing annuity, term of annuity. **Loans:** Principal, interest, term of loan, outstanding balance, final payment (drop payment, balloon payment), amortization, sinking fund.
Bonds: Price, book value, amortization of premium, accumulation of discount, redemption value, par value/face value, yield rate, coupon, coupon rate, term of bond, callable/non-callable.
General Cash Flows and Portfolios: yield rate/rate of return, dollar-weighted rate of return, time-weighted rate of return, current value, duration (Macaulay and modified), convexity (Macaulay and modified), portfolio, spot rate, forward rate, yield curve, stock price, stock dividend
Basic terms in Financial Markets: derivative, underlying asset, over the counter market, short selling, short position, long position, ask price, bid price, bid-ask spread, lease rate, stock index, spot price, net profit, payoff, credit risk, dividends, margin, maintenance margin, margin call, mark to market, no-arbitrage, risk-averse, type of traders.
Options: call option, put option, expiration, expiration date, strike price/exercise price, European option, American option, Bermudan option, option writer, in-the-money, at-the-money, out-of-the-money, covered call, naked writing, put-call parity.
Forwards and Futures: forward contract, futures contract, outright purchase, fully leveraged purchase, prepaid forward contract, synthetic forwards, cost of carry, implied repo-rate.

Method of Teaching and Learning: A combination of lectures and tutorial discussions.

Assessment : Based on tutorials, tests and end of course examination.

Recommended Readings:
1. John C Hull, *Options, Futures and Other Derivatives (10e)*, Pearson, 2017
2. McDonald, R.L., *Derivatives Markets, Addison Wesley*, 2013
3. Robert Kosowski, Salih N. Neftci, *Principles of Financial Engineering*, Academic Press, 2014

Course Code **:** PRPL 31992
Title **:** Professional Placement
Pre-requisites **:** All AMAT course units offered in Level 1 & 2

Learning outcomes:

At the end of the course unit, the student will be able to apply the skills developed over a period of 2 years in the University to the solution of real-life problems in industry, finance and research laboratories.

Course contents:

This course is intended to give students real-world experiences in applications of Mathematics through internships, case studies or projects undertaken by students under supervision of a Department approved personnel from industry, finance or research laboratory.

Method of teaching and learning: Training under the supervision and guidance in a relevant industry for six weeks.

Assessment: Evaluation of the progress report submitted by the trainer and the student's technical report describing the nature of the training and Presentations.

Recommended reading: Reading and reference materials recommended/provided by the relevant industry.

Course Unit Code : AMAT 31613
Course Title : Computational Mathematics
Pre-requisites : AMAT 22582

Learning outcomes:
Upon successful completion of the course unit the student will be able to:
1. investigate the criteria such as convergence, rate of convergence, accuracy and appropriate consistency and stability
2. apply numerical algorithms to solve initial boundary value problems in the form of partial differential equations.

Course Content:
Finite Difference Methods: Introduction to finite difference schemes, Solve parabolic, hyperbolic and elliptic partial differential equations, Dirichlet boundary conditions and Neumann boundary conditions, Convergence: Consistency and Stability using Von Neumann Analysis, Lax Equivalent Theorem.
Finite Element Methods: Variational formulation of problem-classification of partial differential operators, Weighted residual methods: Collocation method, least square method, Galerkin method.
Implementation schemes using appropriate software

Method of Teaching and Learning: A combination of lectures and tutorial discussions.

Assessment : Based on tutorials, tests and end of course examination.

Recommended Readings:

1. Burden, R.L., Faires, J.D, Burden, M.L. *Numerical Analysis (10e)*, Cengage Learning. (2015).
2. A.J. Davies, *Finite Element Method: An Introduction to Partial Differential Equations (2e)*, OUP Oxford (2011)
3. Y. M. Desai, *Finite Element Method with Applications in Engineering.* Pearson Education India (2011)
4. Pavel Ŝolín, *Partial Differential Equations and the Finite Element Method.* (2013)

LEVEL III

Course Unit Code **:** AMAT 32593
Course Title **:** Mathematical Modeling
Pre-requisites **:** PMAT 22572

Learning outcomes:
Upon successful completion of the course unit the student will be able to:
1. explain how the general principals arise in the context of Mathematical Modeling
2. analyze some existing mathematical models and construct simple models for real world situations.
3. explain and apply the basic concepts of Mathematics and their uses in analyzing and solving real-world problems.

Course Content:
Introduction to Modeling: Philosophy of modeling, Modeling Methodology, Problem formulation, Mathematical Description, Analysis, Interpretation
Mathematical Modeling Using Ordinary Differential Equations: Classification of ODE, Equilibrium points, Qualitative analysis of equilibrium points. **First order Differential Equations**: Mixing, chemical reactions, Population models: Logistic growth model, Harvesting models, Traffic Dynamic models: Microscopic and macroscopic models**. System of Differential equations:** Interacting population models (Predator–Prey models, Competition models), Compartment models (Dynamic of infectious disease, Age structured models, Reaction kinetics)
Mathematical Modeling Using Difference Equations: First order difference equations, Equilibrium points, asymptotic stability of equilibrium points, System of linear difference equations: Autonomous systems, Discrete analogue of Putzer algorithm, Jordan form, linear periodic systems
Applications: Markov chains, Population dynamics, Trade models, Age classes, Business cycle models.

Method of Teaching and Learning: A combination of lectures and tutorial discussions.

Assessment : Based on tutorials, tests and end of course examination.

Recommended Textbook:
1. Kapur, J.N., *Mathematical Modeling*, New Age International. (2015).
2. E.A., Bender, *An introduction to Mathematical Modeling*, Courier Corporation, 2012
3. Richard Haberman, *Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow*. SIAM ,(1998)

****

Course Code : AMAT 32623
Title : Introduction to Fluid Dynamics
Pre-requisites: PMAT 22583

Learning Outcomes :
At the end of this course the student will be able to
1. recognize the difference between the discrete mass points and continuous matter in mechanics
2. explain the two dimensional and the axi-symmetrical motion of a perfect fluid.

Course Content :
Further Vector Analysis: Orthogonal curvilinear coordinates, Gradient, Divergence and curl.

Basic Principles of Fluid Dynamics: Fluid pressure, Velocity, Acceleration, Stream lines, Equation of continuity, Euler's equation of Motion, Vorticity, Irrotational motion under conservative forces, Bernoulli's equation, Helmholtz vorticity equation, Vortex lines, Velocity circulation round a closed curve, Cyclic and acyclic motions, Kinetic energy in irrotational motion, Kelvin's theorem, Uniqueness theorems.
Two Dimensional Motion: Stream function and plotting stream lines, Complex potential, Sources and sinks, Vortices, Doublets and image systems, Milne-Thompson theorem.
Axi-symmetric Motion: Stokes' stream function (3D).

Method of Teaching and Learning : A combination of lectures and tutorial discussions

Assessment : Based on tutorials, tests and end of course examination.

Recommended Reading :

1. Feistauer, M. *Mathematical Methods in Fluid Dynamics*, Chapman and Hall/CRC, 1993.
2. A. J. Chorin, J. E. Marsden. *A Mathematical Introduction to Fluid Mechanics*, Springer Science & Business Media, Dec 6, 2012.
3. Dan, H. Martin, B. *Fluid Dynamics Theory and Computation*, Stokholm 2005.
4. Chorlton, F. *Textbook of Fluid Dynamics*, CBS Publishers & Distributors, 2005.

****

Course Code : AMAT 32633
Title : Mathematics for Finance II
Pre-requisites: AMAT 31603

Learning outcomes:
On successfully completion of the course the student will be able to

1. define and recognize the definitions of the financial derivatives
2. calculate the option pricing on various underlying assets
3. solve Black-Scholes equation numerically
4. identify the Greeks and their use
5. identify Swap strategies

Course Contents:
Trading Strategies:
Single option and stock, Spreads and Combinations, Box spreads, Butterfly spreads,
Option Pricing: Binomial Trees: One, two or more binomial periods, Put and Call options, American options, Options on stock index, currencies and future contracts, Risk Neutral pricing, log normality. **The Black-Scholes Formula:** Brownian motion, martingales, stochastic calculus, Ito processes, stochastic models of security prices, Black-Scholes Merton Model, Black-Scholes Pricing formula on call and put options, Applying formula to other assets.
Numerical Solutions to Black-Scholes Equation: Converting to parabolic type, Finite difference methods, FTCS, BTCS and Cranck-Nicholson Schemes for Black-Scholes Equation
Option Greeks: Definition of Greeks, Greek Measures for Portfolios.
Swaps: swap, swap term, prepaid swap, notional amount, swap spread, deferred swap, simple commodity swap, interest rate swap

Method of Teaching and Learning : A combination of lectures and tutorial discussions

Assessment : Based on tutorials, tests and end of course examination

Recommended Readings:

1. John C Hull, *Options, Futures and Other Derivatives (10e)*, Pearson, 2017
2. McDonald, R.L., *Derivatives Markets, Addison Wesley*, 2013
3. Robert Kosowski, Salih N. Neftci, *Principles of Financial Engineering*, Academic Press, 2014

Course Code : AMAT 32643
Title : Mechanics III
Pre-requisites : AMAT 21562

Learning Outcomes:
Upon successful completion of this course, the student will be able to

1. explain, the motion of a dynamical system using Lagrange and Hamilton formalism
2. collect and organize a knowledge of concepts of classical dynamics.

Course Content:
Eularian angles, Motion of a symmetrical top, Normal modes,
Lagrange equation of motion for impulsive motion, D'Alambert's principle.
Hamilton's equations of motion.

Method of Teaching and Learning : A combination of lectures and tutorial discussions.

Assessment: Based on tutorials, tests and end of course examination.

Recommended Reading:

1. J. Daniel Kelley, Jacob J. Leventhal. *Problems in Classical and Quantum Mechanics: Extracting the Underlying Concepts.* Springer. 2016
2. Claude Gignoux, Bernard Silvestre-Brac, *Solved Problems in Lagrangian and Hamiltonian Mechanics*, Springer Netherlands, 2014
3. Chorlton, F. *Text book of Dynamics*, D. Van Nostrand, 1969.
4. Ramsey, A.S. *Dynamics, Parts I & II*, Cambridge University Press, 1975.
5. Goldstein, H. *Classical Mechanics,* Addison Wesley, 1977
6. Anil V. Rao, *Dynamics of Particles and Rigid Bodies: A Systematic approach*, Cambridge University Press. 2006.
7. Dieter Strauch, *Classical Mechanics, An Introduction*, Springer, 2009

B.Sc. Hons

LEVEL IV

Course Code : AMAT 41763
Title : Qualitative and Quantitative Behavior of the Solutions of Ordinary Differential Equations
Pre-requisites : PMAT 22572

Learning Outcomes:
At the end of this course, the student should be able to obtain the numerical solutions of differential equations and their implementations using appropriate software.

Course Contents:
Introduction to Software: Basic procedures in using an appropriate software, Handling numbers and matrices, Control structures, Program design, Script and function files, Plotting.
Basic Properties of the Solutions of Ordinary Differential Equations: Stability of the solution and State-Space Analysis, Qualitative behavior of the solution of Ordinary Differential Equations.
Numerical Solutions of Ordinary Differential Equations: Concept of consistency, Stability and convergence properties of numerical schemes, Single and multistep methods, Solving Stiff systems, Shooting method, Gear's implementation of automatic ordinary differential equation solver, Finite difference discretizations for second order boundary value problems.
Lab work using appropriate software: Algorithms studied in AMAT 21553, AMAT 22562 and in this unit will be implemented using an appropriate software.

Method of Teaching and Learning: A combination of lectures, computer laboratory sessions, tutorial discussions and presentations.

Assessment: Based on tutorials, tests, presentations and end of course examination.

Recommended Reading :

1. Hanselman, D. & Littlefield, B.R.. *Mastering MATLAB*, Pearson Education Limited, (2014).
2. Ferdinand, V. *Nonlinear differential equations and dynamical systems*, Springer Science & Business Media (2012).
3. Vanloan, C.F., *Introduction to scientific computing: a matrix-vector approach using MATLAB*, Prentice Hall, New York. (2000).

Course Unit Code **:** AMAT 41773
Course Title **:** Advanced Computational Mathematics
Pre-requisites **:** AMAT 22582

Learning outcomes:
Upon successful completion of the course unit the student will be able to:
1. Investigate the criteria such as convergence, rate of convergence, accuracy and appropriate consistency and stability
2. Apply numerical algorithms to solve initial boundary value problems in the form of partial differential equations.

Course Content:
Finite Difference Methods: Introduction to finite difference schemes, Solve parabolic, hyperbolic and elliptic partial differential equations, Dirichlet boundary conditions and Neumann boundary conditions, Convergence: Consistency and Stability using Von Neumann Analysis, Lax Equivalent Theorem.
Finite Element Methods: Variational formulation of problem-classification of partial differential operators, Weighted residual methods: Collocation method, least square method, Galerkin method.
Practicals: Implement Finite difference Schemes using an appropriate software, Implement Finite element schemes using Free FEM++

Method of Teaching and Learning : A combination of lectures and tutorial discussions

Assessment : Based on tutorials, presentation, tests and end of course examination

Recommended Textbook:

1. Burden, R.L., Faires, J.D, Burden, M.L. *Numerical Analysis (10e)*, Cengage Learning. (2015).
2. A.J. Davies, *Finite Element Method: An Introduction to Partial Differential Equations (2e)*, OUP Oxford (2011)
3. Y. M. Desai, *Finite Element Method with Applications in Engineering.* Pearson Education India (2011)
4. Pavel Ŝolín, *Partial Differential Equations and the Finite Element Method.* (2013)

Course Unit Code : AMAT 42783
Course Title : Advanced Mathematical Modeling
Pre-requisites : AMAT 41763

Learning outcomes:

Upon successful completion of the course unit the student will be able to:

1. explain how the general principals arise in the context of Mathematical Modeling
2. analyze some existing mathematical models and construct simple models for real world situations.
3. explain and apply the basic concepts of Mathematics and their uses in analyzing and solving real-world problems

Course Content:

Introduction to Modeling: Philosophy of modeling, Modeling Methodology, Problem formulation, Mathematical Description, Analysis, Interpretation
Mathematical Modeling Using Ordinary Differential Equations: Classification of ODE, Equilibrium points, Qualitative analysis of equilibrium points.
First order Differential Equations: Mixing, chemical reactions, Population models: Logistic growth model, Harvesting models, Traffic Dynamic models: Microscopic and macroscopic models
System of Differential equations: Interacting population models (Predator –Prey models, Competition models), Compartment models (Dynamic of infectious disease, Age structured models, Reaction kinetics)
Mathematical Modeling Using Difference Equations: First order difference equations, Equilibrium points, asymptotic stability of equilibrium points, System of linear difference equations: Autonomous systems, Discrete analogue of Putzer algorithm, Jordan form, linear periodic systems
Applications: Markov chains, Population dynamics, Trade models, Age classes, Business cycle models.
Group Project: Mathematical model formulation for a real world problem

Method of teaching and learning : A combination of lectures and tutorial discussions

Assessment : Continuous assessment and/or end of course unit examination

Recommended Textbook:

1. Kapur, J.N., *Mathematical Modeling*, New Age International. (2015).
2. E.A., Bender, *An introduction to Mathematical Modeling*, Courier Corporation, 2012

3. Richard Haberman, *Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow*. SIAM ,(1998)

Course Code : AMAT 42793
Title : Fluid Dynamics
Pre-requisites: PMAT 41763

Learning Outcomes :
At the end of this course the student will
1. recognize the difference between discrete mass-points and continuous matter in mechanics
2. define the fundamental properties of two-dimensional and Axi-symmetric motion, three dimensional motion of a perfect fluid, and motion of a viscous fluid.

Course Content :
Further Vector Analysis: Orthogonal curvilinear coordinates, Gradient, divergence and curl.
Basic Principles of Dynamics: Fluid pressure, Velocity, Acceleration, Stream lines, Equation of continuity, conservation of momentum, conservation of energy, Euler's equations of motion, Bernoulli's theorem, Vorticity, Irrotational motion under conservative forces, Kinetic energy in irrotational motion, Uniqueness theorems, Velocity circulation round a closed curve, Kelvin's theorem, Vortex lines, Helmholtz vorticity equation, Naviers stokes theorem, Cyclic and acyclic motions, Kinetic energy in irrotational motion, Uniqueness theorems.
Two Dimensional Motion: Stream function and plotting stream lines, Complex potential, Sources and sinks, Vortices, Doublets and image systems, Milne-Thompson theorem, Flow past a cylinder, Applications of conformal transformations including Schwarz-Christoeffel transformation, Blassius theorem.
Axi-symmetric Motion: Stokes' stream function (3D).
Three Dimensional Motion: Irrotational motion, Laplace's Equation, Spherical Harmonics, Flow of a stream past a fixed sphere, Motion of a sphere in a fluid, Impulsive motion.

Method of Teaching and Learning : A combination of lectures, tutorial discussions and presentations.

Assessment : Based on tutorials, tests, presentations and end of course Examination.

Recommended Reading :
1. Feistauer ,M. *Mathematical Methods in Fluid Dynamics*, chapman and Hall/CRC,1993.
2. A. J. Chorin, J. E. Marsden. *A Mathematical Introduction to Fluid Mechanics*, Springer Science & Business Media, 2012.
3. Dan, H. , Martin, B. *Fluid Dynamics Theory and Computation*, Stokholm 2005.
4. Chorlton, F. *Textbook of Fluid Dynamics*, CBS Publishers & Distributors, 2005

Course Code : AMAT 42803
Title : Graph Theory
Pre-requisites : PMAT 21553

Learning Outcomes:
At the end of the course the student should be able:
1. recognize the appearance of graphs in real life,

2. identify certain real life situations that can be described using graphs,
3. apply the concepts of graphs to the real world problems.

Course Contents:
Matrices Associated with graphs and their properties, Trees: spanning trees of a connected graph, Coloring: Vertex colourings of graphs: greedy algorithm, Edge colourings of graphs, Matching and covering: Konigs theorem and Halls theorem, connectivity.
Random graphs: properties, Erdos¹s theorem on the existence of graphs with large girth and large chromatic number, the countably infinite random graph.
Group project: Applications related to real world problems

Method of Teaching and Learning: A combination of lectures, tutorial discussions.

Recommended Reading:
1. Robin J. Wilson: *Introduction to Graph Theory (5e)* Longman, 2010
2. Gary Chartrand, Ping Zhang: *A First Course in Graph Theory* Courier Corporation, 2013
3. V. Balakrishnan: *T&P Of Graph Theory (Schaum's outline series)* Tata McGraw-Hill Education, 2004
4. Dragos M. Cvetkovic, Michael Doob, Horst Sachs. Spectra of Graphs: Theory and Applications 3e Wiley, 1999

Course Code : AMAT 41813
Title : Financial Mathematics
Pre-requisites : PMAT 11522

Learning outcomes:
On successfully completion of the course the student will be able to
1. define and recognize the definitions of the financial derivatives
2. calculate the option pricing on various underlying assets
3. solve Black-Scholes equation numerically
4. identify the Greeks and their use
5. identify Swap strategies

Time Value of Money: Simple and Compound Interest, accumulation function, future value, current value, present value, net present value, discount factor, discount rate (rate of discount), convertible monthly, nominal rate, effective rate, inflation and real rate of interest, force of interest, equation of value.

General Cash Flows and Portfolios: yield rate/rate of return, dollar-weighted rate of return, time-weighted rate of return, current value, duration (Macaulay and modified), convexity (Macaulay and modified), portfolio, spot rate, forward rate, yield curve, stock price, stock dividend

Basic terms in Financial Markets: derivative, underlying asset, over the counter market, short selling, short position, long position, ask price, bid price, bid-ask spread, lease rate, stock index, spot price, net profit, payoff, credit risk, dividends, margin, maintenance margin, margin call, mark to market, no-arbitrage, risk-averse, type of traders.

Options: call option, put option, expiration, expiration date, strike price/exercise price, European option, American option, Bermudan option, option writer, in-the-money, at-the-money, out-of-the-money, covered call, naked writing, put-call parity.

Forwards and Futures: forward contract, futures contract, outright purchase, fully leveraged purchase, prepaid forward contract, synthetic forwards, cost of carry, implied repo-rate.

Option Pricing:
Binomial Trees: One, two or more binomial periods, Put and Call options, American options, Options on stock index, currencies and future contracts, Risk Neutral pricing, log normality.

The Black-Scholes Formula: Brownian motion, martingales, stochastic calculus, Ito processes, stochastic models of security prices, Black-Scholes Merton Model, Black-Scholes Pricing formula on call and put options, Applying formula to other assets.

Option Greeks: Definition of Greeks, Greek Measures for Portfolios.

Swaps: swap, swap term, prepaid swap, notional amount, swap spread, deferred swap, simple commodity swap, interest rate swap
Method of Teaching and Learning: A combination of lectures, tutorial discussions and presentations.

Assessment: Based on tutorials, tests, presentations and end of course examination.

Recommended Readings:

1. John C Hull, *Options, Futures and Other Derivatives (10e)*, Pearson, 2017
2. McDonald, R.L., *Derivatives Markets, Addison Wesley*, 2013
3. Robert Kosowski, Salih N. Neftci, *Principles of Financial Engineering*, Academic Press, 2014

Course Code : AMAT 41823
Title : Quantum Mechanics
Pre-requisites : AMAT 11513

Learning Outcomes:
At the end of this course, the student should be able to demonstrate knowledge of concepts and principles of quantum mechanics and to apply them to solve simple problems.

Course Contents:
Quantum mechanics in Hilbert space, Axiomatic structure of quantum mechanics, The Shrödinger picture, Heisenberg and interaction picture, Complete set of observables, formalism of wave mechanics and its applications, Completely continuous operators, uncertainty principle, potential well, simple harmonic oscillator, scattering theory of two particles, potential scattering, approximate methods

Method of Teaching and Learning: A combination of lectures, tutorial discussions and presentations.

Assessment: Based on tutorials, tests, presentations and end of course examination.

Recommended Reading :

1. Schiff, L.I., *Quantum Mechanics (4e)*, McGraw-Hill India. (2014).
2. Prugovecki, E., *Quantum Mechanics in Hilbert Space (2e)*, Courier Corporation, 2013
3. Liboff R, L., *Introductory Quantum Mechanics*, (4e) Pearson India (2011).
4. Baggot, J., *The meaning of Quantum Theory*, Oxford University Press. (1997).
5. Sakurai, J.J., *Advanced Quantum Mechanics*, Replica Press (P) LTD, India. (2013).

Course Code : AMAT 43976
Title : Research/Study Project

Learning Outcomes:
At the end of this course, the student should be able to demonstrate competence in research/independent-study in an area in Applied Mathematics.

Course Contents:
Undergraduate research project is an inquiry, investigation, or creation produced by a final year honours degree undergraduate that makes a contribution to the discipline and reaches beyond the traditional curriculum. Undergraduate research project is designed to provide students with the opportunity to develop and practice advanced discipline-specific projects in collaboration with senior academics in the department.

Method of Teaching and Learning: A research/study project under the supervision of a senior staff member of the department.

Assessment: Submission of a research/study project report and an oral presentation.

Recommended Reading : Required reading material will be recommended by the supervisor depending on the relevant project.

Course Unit Code : AMAT 41833
Course Title : Linear programming and Optimization
Pre-requisites : PMAT 21553

Learning outcomes:
Upon successful completion of the course unit the student will be able to:
1. develop a linear programming model from problem description,
2. use the simplex method for solving linear programming problems,
3. use the revised simplex method to solve linear programming problems,
4. interpret the dual of a linear programming problem and solve the resulting dual problem using the dual simplex method,
5. obtain the solution to the primal problem from the solution of the dual problem
6. use methods of linear programming for solving assignment problems and transportation problems
7. identify the convex functions
8. solve optimization problems in various areas using linear and non-linear programming methods

Course Content:
Optimization, Types of optimization problems,
Linear Programming: Formulate linear programming problem: Extreme Points, Basic Feasible Solutions, Solutions using graphical methods, Simplex method, Revised simplex method, Duality theory, Primal and dual problems, Reduction of linear inequalities, Hungarian method, Big m method.
Non Linear programming: Types of non-linear programing, Convex and concave functions, one variable unconstrained optimization, multivariable unconstrained optimization, Convex programming
Applications of Linear Programming Problems: Transportation problem and Assignment problem
Implement Linear programming problems using Excel

Method of Teaching and Learning: A combination of lectures, tutorial discussions and presentations.

Assessment: Based on tutorials, tests, presentations and end of course examination

Recommended Textbook:

1. David G. Luenberger, *Linear and Nonlinear Programming,* (4e) Springer; 2016
2. Jiri Matousek, Bernd Gärtner, *Understanding and Using Linear Programming.* Springer Berlin Heidelberg, 2009
3. F. S. Hillier and G. Lieberman, *Introduction to Operations Research,* McGraw-Hill, (10e). 2015

Course Code : AMAT 42843
Title : Quantum Field Theory
Pre-requisites : AMAT 41823

Learning Outcomes:
At the end of this course, the student should be able to demonstrate knowledge of basic properties of relativistic local field theory and the quantization of spin zero and spin half fields.

Course Contents:
Relativistic wave equation, Review of mechanics of a finite system, Quantisation, General Theorems, Quantisation of spin zero fields and spin ½ fields, Momentum and angular momentum operators, Phase factor, Conventions between the spinners, Two - component theory.

Method of Teaching and Learning: A combination of lectures, tutorial discussions and presentations.

Assessment: Based on tutorials, tests, presentations and end of course examination.

Recommended Reading :

1. Schiff, L.I., *Quantum Mechanics (4e)*, McGraw-Hill India. (2014).
2. Prugovecki, E., *Quantum Mechanics in Hilbert Space (2e)*, Courier Corporation, 2013
3. Lee, T. D., *Particle Physics and Introduction to Field Theory,* Taylor and Francis. (1981).

Course Code : AMAT 42853
Title : Tensor Analysis and General Relativity
Pre-requisites : PMAT 21553

Learning Outcomes:
At the end of the course the student should be able to demonstrate knowledge of concepts and theorems in tensor algebra, tensor analysis and the formalism of general relativity, and to solve Einstein’s field equations in simple cases, and to apply the solutions in Astrophysics.

Course Contents:
Covariant and contravariant vectors, Metric tensor, Invariants, Inner products, Differential-forms, Tensor analysis, Covariant differentiation of tensors, Einstein’s field equations, Schwarzchild interior and exterior solutions, Rotating systems, Dragging of inertial frames, Gravitation red shift, Bending of light and gravitational lenses.

Method of Teaching and Learning: A combination of lectures, tutorial discussions and presentations.

Assessment: Based on tutorials, tests, presentations and end of course examination.

Recommended Reading:

1. Adler R., Bazin M. and Schiffer M., *Introduction to General Relativity,* McGraw Hill, New York. (1975).
2. Misner, C.W.,Thorne, K.S. & Wheeler, J.A., *Gravitation*, Princeton University Press, 2017.
3. Hawking S.W. & Ellis G.F.R., *The Large Scale Structure of Space-time,* Cambridge University Press. (1975).
4. James B. Hartle, *Gravity: An Introduction to Einstein's General Relativity*, Pearson (2013).

/////////////////////////////////**....**\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\