MTH-3D27: History of Mathematics (for 2014-15)

1. Introduction: The module will trace the developments of Algebra and Calculus, from ancient times to the 21st century. The emphasis lies on selected intellectual developments of mathematics and their connection with contemporary research.

2. Timetable hours, Credits, Assessments: This is a 20 UCU module of 33 lectures. The overall mark comes from coursework (20%) and one three-hour examination (80%).

3. Overview: There are two parts: 11 lectures on Algebra; 22 lectures on Calculus. In Part I we trace the development of Arithmetic and Algebra from the high cultures of the Egyptian Middle Kingdom and Mesopotamia (1600BC) through to Islamic mathematics and early algebra and to the beginnings of mathematical modernity in the work of Galois in the 1830's. Our style will be to explore and understand mathematical practice and conceptual developments in different historical contexts.

For the 22 lectures of Part II we present the Rise of the Calculus: this is taken first from the Paradoxes of Zeno and the work of Euclid and Eudoxus on axioms relevant to fundamental ideas of the calculus. The work of Archimedes on the method of exhaustion is covered in detail with examples of the rigorous calculation of plane area (e.g. segment of parabola), surface area and volume (e.g. sphere). We take this onwards to trace the development of ideas on series summation, differentiation and integration in the 16^{th} and 17^{th} centuries. We look in detail at the many methods of tangents and normals, as described by Descartes and Fermat, Wallis and Barrow, in the 17th century. We discuss the synthesis of differentiation and integration achieved by Newton and Leibniz around 1700. We end with reviewing later developments of the branches of the calculus in 18^{th} century and later.

4. Recommended Reading:

John Fauvel and Jeremy Gray, 'The History of Mathematics – A Reader', Open University, 1987.

http://en.wikipedia.org/wiki/History–of–mathematics

Part I: B.L. Van Der Waerden, 'Science Awakening', Noordhoff Ltd., Groningen, Chaps. 1-3.

B.L. Van Der Waerden 'History of Algebra', , Springer Verlag, Chaps. 1-4.

http://www.gap-system.org/ ˜history/Indexes/HistoryTopics.html
http://en.wikipedia.org/wiki/Egyptian−mathematics
http://en.wikipedia.org/wiki/Babylonian−mathematics
http://en.wikipedia.org/wiki/Mathematics−in−medieval−Islam

Part II: U.C. Merzbach & C.B. Boyer, 'A History of Mathematics', Wiley 3rd edition, 2011, chaps 4--7 & 14—16. (Boyer & Merzbach for 2nd edition, 1991, chaps 8–9 and 17–19.) This is also an E-Book, see UEA Main Library Catalogue.

5. Lecture Contents:

Part I: Arithmetic and Algebra: An Introduction: Early Mathematics. (1 Lecture)
Arithmetic in the Middle Kingdom, Egypt 1600 BC. (2 Lectures)
Algebra & Geometry at the time of Hammurabi, Mesopotamia 1700BC. (2 Lectures).
Islamic Algebra 750-1200AD, Al Khwarizmi. (1 Lecture)
Algebra in the Renaissance, 1400-1600. (2 Lectures)
Developments up to Galois 1832. (2 Lectures).

Part II: The Rise of the Calculus:
Introduction to ideas of Calculus: Zeno's Paradoxes, Euclid & Eudoxus. (4 lecs).
Method of Exhaustion. The area and volume calculations of Archimedes on circle, parabola, sphere, spiral. (4 lecs). Apollonius of Rhodes (2 lecs)
Summation of series and other contributions to calculus. (1 lec)
Infinitesimals and the work of Cavalieri, Kepler, Viete etc. (2 lecs)
Tangents, quadratures and summations in early 17th century: Fermat, Descartes, Roberval, Wallis, Barrow etc. (4 lecs)
The calculus of Newton & Leibniz in late 17th early 18th centuries. (2 lecs).
The later developments of the branches of the calculus. (1 lec).

MTH-3D79 : Free Surface Flows

1. Introduction: This course provides an introduction to the theory of free surface flows, in particular of water waves, liquid jets and liquid sheets. It requires some knowledge of hydrodynamics and multivariable calculus. The unit is suitable for those with an interest in Applied Mathematics.

2. Timetable Hours, Credits, Assessments: 20 credits(UCU) assessed by a three-hour examination (80%) and by coursework (20%). There will be 33 lectures.

3. Overview: Free surface problems occur in many aspects of science and everyday life. Examples of free surface problems are waves on a beach, bubbles rising in a glass of champagne and a liquid jet flowing from a tap. In these examples the free surface is the surface of the sea, the interface between the gas and the champagne and the boundary of the falling jet. We will study aspects of linear and nonlinear water waves using analytical techniques. In the second part we will investigate the dynamics and breakup of liquid jets or sheets using linear stability analysis.

4. Recommended literature and references (The notes taken in lectures are intended to be complete and self-contained):

J. Billingham and A.C. King, *Wave Motion,* Cambridge Univ. Press, 2000.
G.B. Whitham, *Linear and nonlinear waves,* Wiley, 1999.
J.-M. Vanden-Broeck*, Gravity-Capillary Free-Surface Flows,* C.U.P., 2010.
P. Drazin, *Introduction to hydrodynamic stability,* C.U.P., 2002.
S.P.Lin, *Breakup of Liquid Sheets and Jets,* C.U.P., 2003.
James Lighthill, *Waves in Fluids*, C.U.P., 2001.
R. S. Johnson - *A Modern Introduction to the Mathematical Theory of Water Waves,* C.U.P., 1997.

In addition, material may be taken from recent journal articles and appropriate references will be given during the lectures.

5. Lecture Contents:

Introduction and overview: Equations and boundary conditions, the concept of surface tension.
(3 lectures)

A. Theory of water waves.
- Linear aspects: dispersion relation and group velocity, wave energy, wave shoaling, the wavemaker problem, initial value problems, gravity-capillary waves.

(10 lectures)

- Nonlinear waves: Stokes periodic waves, solitary waves, shallow-water approximations, model equations (Korteweg-de Vries equation, nonlinear Schrödinger equation).

(10 lectures)

B. Theory of liquid jets and sheets: Linear stability analysis. One-dimensional approximations. Liquid sheets

(10 lectures)

MTH-3E22: Set theory

1. Introduction: This unit is concerned with foundational issues in mathematics and provides the appropriate mathematical framework for discussing 'sizes of infinity'. On the one hand we shall cover concepts such as ordinals, cardinals, and the Zermelo-Fraenkel axioms with the Axiom of Choice. On the other, we shall see how these ideas come up in other areas of mathematics, such as graph theory and topology. Familiarity with and a taste for mathematical proofs will be assumed. Therefore, second year **Analysis** is a desired prerequisite.

2. Timetable, Hours, Credits, Assessments: The unit is a 20 UCU unit. Assessment is by a written exam (80%) and a coursework (20%).

3. Overview: Set theory plays a dual role in mathematics. It provides a manageable foundation to mathematics and it is itself a sophisticated area of mathematics.

The foundational role of set theory consists in providing a reasonable set of assumptions (axioms) which enable us to construct most mathematical objects, and from which most mathematics can be derived by proving theorems based on these axioms. We will discuss this system of axioms, known as ZFC (Zermelo-Fraenkel Axioms with the Axiom of Choice), and will demonstrate how it can be used to build the foundations of mathematics. We will discuss some background foundational issues, including Gödel's Incompleteness Theorems and the notion of consistency (these issues will be discussed without proofs), and will discuss some alternatives to ZFC.

We shall also see how set theory provides the right framework for studying infinite sets. Examples of such sets are the set of all natural numbers, the set of all rationals, and the set of all real numbers. It turns out that there is a very natural way to assign a notion of size to such sets, providing us with more information than just 'infinite'. According to this notion (*cardinality),* the first two of the above sets have the same size, which is strictly smaller than that of the third. We will construct some concrete examples of infinite objects in mathematics, such as infinite graphs, almost disjoint families, topological spaces, and groups, and will study some of their properties.

Finally, if we have time we will briefly discuss the construction of different models of the axioms of set theory and will discuss the limitations of ZFC as well as criteria for extending ZFC in a sensible way.

4. Recommended Reading: The unit is self-contained. The student is advised to attend regularly, as the teaching will include a lot of discussion. Lecture notes will be produced as we go and will be clear and self-sufficient. For supplementary reading the following books may be useful:

1. A. Hajnal and P. Hamburger, Set Theory, Cambridge, 1999.
2. P. Halmos, Naive Set Theory, Springer UTM.

5. Rough lecture contents:
Cardinality, naive set theory and paradoxes **(3 lectures)**
The axioms of ZFC **(5 lectures)**
Orderings and well ordered sets, ordinals **(4 lectures)**
Infinite objects **(2 lectures)**
Cardinals and basic cardinal arithmetic **(4 lectures)**
Transfinite recursion and induction (**4 lectures)**
Some applications of the axiom of choice **(5 lectures)**
Models of set theory **(4 lectures)**
Foundational discussion **(2 lectures)**

MTH-3E29: Galois Theory

1. Introduction: This module is an introduction to Galois Theory, which beautifully brings together the notions of a group and of a field, from 2C3Y Algebra. In particular, the ideas developed will be applied to looking at the question of solving polynomial equations.

2. Hours, Credits and Assessment: A 20 UCU module of 33 lectures, supported by office hours. Assessment is based on coursework (20%) and examination (80%).

3. Overview: Galois theory is one of the most spectacular mathematical theories. It gives a beautiful connection between the theory of polynomial equations and group theory. In fact, many fundamental notions of group theory originated in the work of Galois. For example, why are some groups called "solvable"? Because they correspond to the equations which can be solved (by some formula based on the coefficients and involving algebraic operations and extracting roots of various degrees). Galois theory explains why we can solve quadratic, cubic and quartic equations, but no similar formulae exist for equations of degree greater than 4. In modern exposition, Galois theory deals with "field extensions", and the central topic is the "Galois correspondence" between extensions and groups.

4. Recommended literature and references: Suitable books include

Stewart, I., Galois Theory, Chapman and Hall. [QA214STE]

Artin, E., Galois Theory, Dover.

Cohn, P.M., Algebra Vol. 1, Wiley. [QA154COH]

Herstein, I.N., Topics in Algebra, Wiley. [QA154HER]

Snaith, V.P., Groups, rings and Galois theory, World Scientific. [QA171SNA]

5. Lecture Contents:
Fields and polynomial rings; irreducibility of polynomials and irreducibility criteria for polynomials over Q; maximal ideals and construction of algebraic field extensions; degree; tower law; splitting fields. (9 lectures)

Artin's Extension Theorem, separability, inseparability, Primitive Element Theorem. (5 lectures)

Normal and Galois extensions, the Fundamental Theorem of Galois Theory, examples of the explicit computation of Galois groups. (7 lectures)

Radical extensions, solvable groups, proof that a polynomial can be solved using radicals if and only if the associated Galois group is a solvable group, radical solution to general quadratic, cubic and quartic equations, explicit examples of polynomials which are not solvable by radicals. (7 lectures)

Finite fields: basic structure of finite fields, all extensions of finite degree are Galois with cyclic Galois group. (5 lectures)

MTH-3E23: Graph Theory

1. Introduction: This module is a thorough introduction on modern Graph Theory. This subject plays an important role in many branches of mathematics and the sciences generally. Graph Theory therefore has applications almost everywhere. There are no formal prerequisites from MTH Year 2 modules.

2. Hours, Credits and Assessment: The module is a 20 UCU module of 33 lectures and additional time for group discussions on demand. Assessment is based on a three-hour examination and course work.

3. Overview: Graphs are among the most basic structures in mathematics. A graph consists of a set of points, the *vertices* of the graph, and a set of *edges* which link certain pairs of vertices. By their very simplicity it is therefore not surprising that graphs are important in many part of mathematics, computing and the sciences.

This module is designed as an introduction to the theory of graphs. Thus we first develop the basic notions of connectivity and matchings. Graphs appear also in topology and these aspects will be investigated in a section on planarity. This addresses the question if a graph can be drawn in the plane in such a fashion that edges do not intersect except at a vertex. We shall aim to prove a famous theorem due to Kuratowski which provides the exact conditions for the planarity of a graph.

An important area of interest are graph colourings. These are assignments of 'colours' to the edges of the graphs in such a way that two different edges of the same colour never meet at a vertex. There are also vertex colourings where vertices of the same colour may not be joined by an edge. Such questions lead to many beautiful results and interesting applications. One of the best known theorems in graph theory is the Four-Colour-Theorem. While this result is not within our reach we shall aim to prove the Five-Colour-Theorem.

The module is based on Diestel's book below, and this text will be the designated course text.

4. Recommended literature and references: The literature on the subject is extensive. We will be using the first book as the main course text. (Booksellers can be found at http://www.AbeBooks.co.uk)

R Diestel "Graph Theory", Springer Graduate Texts in Mathematics 173. Electronic searchable versions are available.

NL Biggs "Discrete Mathematics", OUP, (a very useful introductory text)
JA Bondy, USR Murty "Graph Theory" Springer GTM 244 (a comprehensive text)
NL Biggs "Algebraic Graph Theory", CUP

5. Lecture Contents:

Basics: Definitions, subgraphs, trees, Euler circuits, cycle. **(9 lectures)**

Matchings: The theorems of König and Hall. **(5 lectures)**

Connectivity : k-connected graphs, Menger's theorem. **(5 lectures)**

Planarity: Basic topological ideas, introduction to Kuratowski’s theorem. **(6 lectures)**

Colourings: vertex colourings, edge colourings, the 5-colour theorem. **(8 lectures)**

MTH-3E46: Dynamical Oceanography

1. Introduction: This level 3 module covers modelling the large scale ocean circulation and structure, internal waves and coastal flows. It requires prior completion of second level modules, either **MTH-2C5Y** or **ENV-2A61.**

2. Timetabled Hours, Credits, Assessment: This is a 20 credit module of 33 lectures. Assessment is based on a three-hour examination (80%) and two pieces of coursework (20%).

3. Overview: The mathematical modelling of the oceans in this module provides a demonstration of how the techniques developed in second year modules on fluid dynamics and differential equations can be used to explain some interesting phenomena in the real physical world. The module begins with a discussion of the effects of rotation in fluid flows. The dynamics of large scale ocean circulation is discussed including the development of ocean gyres and strong western boundary currents. The thermal structure associated with these flows is examined. These large scale currents are responsible for the variation in climate between land on the eastern and western side of major ocean basins. The dynamics of equatorial waves are examined. Such waves are intimately linked with the El Niño phenomena which affects the climate throughout the globe.

4. Recommended texts: There are no set textbooks for the module. However there are a number of useful books for background reading and reference in library (as both hard copy and e-books). The following are particularly recommended:

A Gill	"Atmosphere-Ocean Dynamics", (Academic Press)
G Vallis	“Atmospheric and Oceanic Fluid Dynamics”, (Cambridge)

5. Lecture Contents:

Introduction: Equations of motion. Rotation. Geostrophic flow. Rossby and Ekman numbers. Geostrophic and hydrostatic balances. Stratification and its impact on flows. The Sverdrup relation. **(5 lectures)**

Abyssal Circulation. Stommel Arons Theory and circlulation of deep and bottom waters. **(3 lectures)**

Gyre models: Wind-driven ocean circulation. Surface Ekman layer. Ekman transport and suction. Sverdrup interior circulation. Stommel boundary layer. **(7 lectures)**

Southern Ocean Dynamics: Antarctic Circumpolar Current. Steady circulation with topography. Unsteady circulation without topography. Ertel's theorem. **(6 lectures)**

Internal waves: Coastal and equatorial Kelvin Waves. Rossby Waves. **(6 lectures)**

Equatorial dynamics: Kelvin and Rossby waves. **(6 lectures)**

MTH-3E58: Semigroup Theory

1. Introduction: This module is an introduction to Semigroup Theory. Semigroups are algebraic objects which generalize groups (seen in Algebra 2C3Y). They are of interests because they arise naturally in many parts of mathematics, for example, whenever we are composing functions, multiplying matrices, or considering homomorphisms between objects, there are semigroups underlying our mathematics.

2. Hours, Credits and Assessment: A 20 UCU module of 33 lectures, supported by office hours. Assessment is based on coursework (20%) and examination (80%).

3. Overview: This module is concerned with the study of a class of algebraic objects called semigroups. A semigroup is an algebraic structure consisting of a set together with an associative binary operation. For example, every group is a semigroup, but the converse is far from being true. This course will cover the fundamentals of semigroup theory, with a focus on studying the structure of semigroups by looking at their ideals, and at the groups that embed into them.

4. Recommended literature and references: The main reference is:

J. M. Howie. *Fundamentals of semigroup theory*, Academic Press [Harcourt Brace Jovanovich Publishers], London, 1995. L.M.S. Monographs, No. 7.

Other useful books include:

A. H. Clifford and G. B. Preston, *The algebraic theory of semigroups. Vol. I & II, Mathematical Surveys*, No. 7. American Mathematical Society, Providence, R.I. 1961.

G. Lallement, *Semigroups and Combinatorial Applications*, John Wiley & Sons, New York, 1979.

M. V. Lawson, *Inverse Semigroups: The Theory of Partial Symmetries*, World Scientific, 1998.

J. Rhodes & B. Steinberg. *The q-theory of finite semigroups*. Springer Monographs in Mathematics. Springer, New York, 2009.

5. Lecture Contents: Basic definitions and examples of semigroups and monoids: transformation semigroups, partial transformations, semigroup of binary relations, symmetric inverse semigroup, full linear monoid, bands, rectangular bands, semilattices. Subsemigroups, homomorphisms and congruences; First Isomorphism Theorem; Cayley's Theorem; direct products of semigroups. **(7 lectures)**

Ideals and Rees congruences; principal left and right ideals; Green's relations; Green's Lemma; maximal subgroups of semigroups; von Neumann regularity; semigroup inverses; D-class structure and egg-box diagrams; partially ordered sets of R, L and J-classes. **(8 lectures)**

Simple and 0-simple semigroups; principal factors; completely simple and completely 0-simple semigroups; the Rees matrix construction; the Rees-Sushkevich Theorem. **(7 lectures)**

Inverse semigroups; semilattices; Brandt semigroups; bicyclic monoid; symmetric inverse semigroup and Vagner-Preston Theorem, Clifford monoids, Bruck-Reilly extensions. **(6 lectures)**

Free semigroups; presenting semigroups with generators and relations; free groups; free inverse semigroups and Munn trees. **(5 lectures)**

MTH-3E60: INTRODUCTION TO NUMERICAL ANALYSIS WITH ADVANCED TOPICS

1. Introduction: This is an introductory course in numerical analysis that will cover approximating a function and it's derivative numerically. Further topics will include the numerical solution to boundary and initial value problems, numerical integration and nonlinear equations. Advanced topics will include an introduction to the numerical solution to hyperbolic partial differential equations.

2. Timetable Hours, Credits, Assessments: 20 credits(UCU) assessed by a three-hour examination (80%) and by coursework (20%). This module is mainly lecture based with two (required) scheduled lab sessions.

3. Overview: The modelling of many physical phenomena involve equations that may not have closed form solutions. For example, blood flow through the heart or turbulence in the wake of an aircraft. For these examples we resort to numerical simulations. This module is designed to introduce the basics of numerical simulation used in more complex modelling.

4. Recommended literature and references (The notes taken in lectures are intended to be complete and self-contained):

R. Burden and J.D. Faires, *Numerical Analysis,* Brooks/Cole, 2010.
A. Quarteroni, F. Saleri and P. Gervasio, *Scientific Computing with MATLAB and Octave,* Springer, 2010.
E. Isaacson and H.B. Keller, *Analysis of Numerical Methods,* Dover, 2003.

5. Lecture Contents:

Introduction and overview: Motivation and review of important theorems.

(2 lectures)

A. Solving to Nonlinear equations: Bisection method, Fixed point iteration and the Newton-Raphson scheme. Comparison of the effectiveness of these methods and the expected convergence.

(4 lectures)

B. Approximating functions and derivatives using Taylor series and Interpolation and their expected convergence rates.

(4 lectures)

C. Numerical integration: Midpoint, integral and trapezoidal rule. Obtaining higher accuracy through Gauss quadrature. Convergence

(4 lectures)

D. Numerical ODEs and Finite Difference schemes: Single-step schemes (Euler, Modified Euler, Trapezoidal). Local truncation and round-off error. Consistency and stability. Aspects of Linear Algebra that are important in computing

(~10 lectures)

E. Further Advanced topics: Issues important in solving hyperbolic partial differential equations.

MTH-3E77 : Financial Mathematics

1. Introduction: This module is primarily concerned with the valuation of certain financial instruments known as derivatives. It has great application to finance and banking. The module assumes some knowledge of differential equations and MTH-2C6Y Differential Equations and Applied Methods, or ENV-2A62, or equivalent, is a prerequisite. Some of the mathematical modelling is stochastic but no prior knowledge of probability or statistics is assumed. Neither is any previous background in finance theory necessary.

2. Timetable Hours, Credits, Assessments: This module is of 20 UCU and is taught in the Autumn Semester by 33 lectures. Regular question sheets will be handed out, and assessment is 20% on course work and 80% by a three-hour examination.

3. Overview: The Mathematical Modelling of Finance is a relatively new area of application of mathematics yet it is expanding rapidly and has great importance for world financial markets. The module is concerned with the valuation of financial instruments known as derivatives. Introduction to options, futures and the no-arbitrage principle. Mathematical models for various types of options are discussed. We consider also Brownian motion, stochastic processes, stochastic calculus and Ito's lemma. The Black-Scholes partial differential equation is derived and its connection with diffusion brought out. It is applied and solved in various circumstances.

4. Recommended Reading:

Any of the following should prove useful, especially the first two:

1) Paul Wilmott introduces quantitative finance, 2nd ed.
   P. Wilmott. Wiley, 2007.

   This is also available as an e-book in the library.

2) The mathematics of financial derivatives
   P. Wilmott, S. Howison, J. Dewynne. CUP, 1995.

3) An elementary introduction to mathematical finance, 2nd ed.
   S.M. Ross. CUP, 2003.

4) A course in financial calculus
   A. Etheridge. CUP, 2002.

5) The concepts and practice of mathematical finance
   M. Joshi. CUP, 2003.

5. Lecture Contents:

Introduction to options, futures and the no-arbitrage principle - using this to calculate fair delivery prices for futures. **(6 lectures)**

Basic probability theory. **(2 lectures)**

The Binomial Model for random asset prices and option valuation. **(5 lectures)**

Basics of stochastic calculus and Ito's lemma. Brownian motion and geometric Brownian motion. Stochastic and deterministic processes. **(4 lectures)**

The Black-Scholes analysis. Derivation of the Black-Scholes partial differential equation and the assumptions behind it (i.e. Hedging and no-arbitrage). Formulating the mathematical problem, determining boundary conditions for option pricing problems. **(4 lectures)**

Solving the Black-Scholes equation. Connection with heat conduction equation, solution of the heat conduction equation - similarity solutions and the Dirac delta function. Derivation of the price of European options. European options with continuous dividend yield. **(5 lectures)**

The Greeks. Barrier options. More than one asset. American options. **(7 lectures)**

MTHA6005Y : Mathematics project

1. Introduction: This module gives the students the opportunity to work on a project of their own choosing.

2. Timetable, Hours, Credits, Assessments: The module is a 20 UCU year long module with 90% of the marks given for the written report and 10% given for an oral presentation.

3. Overview: The students each pick a topic from a list of subjects offered by members of faculty. Each project will give a suggested reading list, but students are encouraged to find new sources for themselves. The students will each write a project report which is up to 18 pages long and which will be submitted towards the end of the semester. There will be lectures on how to write the project and an informal presentation session to practise talks, and the students will have four meetings with their supervisor. The mathematics in the project will not be taught.

MTH-3T03: The learning and teaching of mathematics

1. **Introduction:** The aim of the module is to introduce students to the study of the teaching and learning of mathematics with particular focus to secondary and post compulsory level; to explore theories of learning and teaching of mathematical concepts typically included in the secondary and post compulsory curriculum and to explore mathematics knowledge for teaching. This module is recommended for anyone interested in Mathematics teaching as a career or, indeed, for anyone interested in mathematics education as a research discipline.

2. **Timetable hours, Credits, Assessments:** A 20 UCU module of 20 lectures and 20 hours seminars over 10 Weeks in the Autumn Semester. The overall mark comes from module course work (40%) and one two-hour course test (60%). Module leader: Paola Iannone (p.iannone@uea.ac.uk).

3. **Overview:** The module will start with the exploration of mathematics education as an academic discipline. The main theories of learning and teaching mathematics will be addressed during the module, with focus on teaching and learning mathematics concepts included in the secondary and post-compulsory curriculum. The context of school will also be investigated with particular reference to the secondary mathematics curriculum and the role of formative and summative assessment. Preparation for Initial Teacher Training will be discussed, and the module will end with an exploration the public perception of mathematics and how this impacts on pupils' attitudes towards the subject and uptake of mathematics at post-compulsory level.

4. **Recommended Reading:** Students will receive recommended readings from the research literature each week and the readings will also be posted on the Portal site. A useful reference book is

   Tall, D. (1991) *Advanced mathematical thinking,* Kluwer.

5. **Lecture Contents:**

Introduction to the study of teaching and learning mathematics What is research in mathematics education?	**(2 lectures)**
Theories of learning mathematics: the developmental approach	**(8 lectures)**
Mathematics knowledge for teaching	**(2 lectures)**
Sociocultural approaches to mathematics education	**(2 lectures)**
Institutional context: the secondary school curriculum, Educational policy in recent years	**(2 lectures)**
Assessment in school, formative and summative assessment, impact on students' learning	**(2 lecture)**
Public understanding of mathematics: pupils' and teachers' attitudes towards mathematics.	**(2 lectures)**