School of Mathematics

Module MA1M01 — Mathematical Methods (JF Natural Science)

Lecturer: Prof. Sinéad Ryan, Prof. Esther Vergara Diaz

Requirements/prerequisites: none

Duration: Michaelmas term, 11 weeks

Number of lectures per week: 8 hours per week total, including 5 lectures, 2 tutorials and 1 computer practical.

Assessment: Tutorial work and computer practical work will count 25% of the marks.

ECTS credits: 10

End-of-year Examination: 3 hour examination in Trinity term (for 75% of the total marks).

Description: The syllabus is largely based on [Bittinger-G-N].

Calculus for Life Scientists

This part will be lectured by Prof. Vergara Diaz and there will be 3 lectures plus one tutorail per week.

The syllabus is approximately Chapter 1-5 along with a little of Chapter 8 on differential equations (sections 8.1 and 8.2) from [Bittinger-G-N].

- Functions and graphs. Lines, polynomials, rational functions, trigonometric functions and the unit circle.
- Differentiation. Limits, continuity, average rate of change, first principles definition, basic rules for differentiation.
- Graphical interpretation of derivatives, max/min.
- Exponential and log functions. Growth and decay applications.
- Integration (definite and indefinite). Techniques of substitution and integration by parts. Applications.
- Differential equations and initial value problems, solving first order linear equations. Some application in biology or ecology.

Discrete Mathematics for Life Scientists

Prof. Ryan will be the lectuer for this part. There will be 2 lectures per week, one tutorial and, for several of the weeks, a computer practical.

The syllabus is approximately:

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- Linear algebra. Matrices, solving systems of linear equations, inverse matrices, determinants, eigenvalues and eigenvectors, solving difference equations. Population growth. (Chapter 6 of [Bittinger-G-N].)
- Spreadsheets. Basic concept of programming formulae in a spreadsheet such as Excel (absolute and relative cell references, some typical built in functions like sum, count, if). Formula for least squares fit of a line to points in the plane (without justification?). Graphs. Use of log scales.
- *Data.* Scientific notation, number of significant digits, relative error. Sample mean, median, sample variance.
- *Probability.* Basic concepts of probability. The binomial distribution, expectation and standard deviation for discrete random variables. (Sections 10.1, 10.3, 10.4 of [Bittinger-G-N].)

Textbook:

[Bittinger-G-N] Calculus for the Life Sciences. Marvin Bittinger, Neal Brand, John Quintanilla. Pearson Dec 2005

Learning Outcomes: On successful completion of this module, students will be able to:

- plot the graph of a function, numerically;
- estimate derivatives and definite integrals from a graph;
- compute the equation of a straight line given the slope and a point on the line, or two points on the line, or equivalent information;
- find a function $f(t) = k + a\cos(bt)$ or $f(t) = k + a\sin(bt)$ which may be used as a simple model for some periodic phenomenon, given the amplitude, average value and period, or equivalent information;
- differentiate functions obtained from roots, rational powers, composition, constants, arithmentic operations and the functions sin, cos, exp and log using the standard differentiation rules;
- find indefinite and definite integrals of functions in the same class, including the use of substitution and integration by parts;
- Manipulate and simplify expressions involving roots, rational powers, exp and log, and solve equations involving these.
- solve simple maximisation/minimisation problems using the first derivative test;
- apply a basic understanding of the fundamental theorem of calculus, for example to solve differential equations and initial value problems of the form dy/dx = f(x);

- select the correct method from those covered in the module to solve wordy calculus problems, including problems based on population dynamics and radioactive decay;
- algebracially manipulate matrices by addition and multiplication and use Leslie matrices to determine population growth;
- solve systems of linear equations by Gauss-Jordan elimination;
- calculate the determinant of a matrix and understand its connection to the existence of a matrix inverse;
- use Gauss-Jordan elimination to determine a matrix inverse;
- determine the eigenvalues and eigenvectors of a matrix and link these quantities to population dynamics;
- state and apply the laws of probability;
- determine the results of binomial experiments with discrete random variables;
- calculate probabilities using probability density functions for continuous random variables.

October 18, 2011