MODULE TITLE	**Vector Calculus and Applications**	**CREDIT VALUE**	**15**
MODULE CODE	**MTH2004**	**MODULE CONVENER**	**Dr Tim Jupp (Coordinator)**

DURATION: TERM	**1**	**2**	**3**
DURATION: WEEKS		**11**	

Number of Students Taking Module (anticipated)	**250**

DESCRIPTION - summary of the module content

This module introduces vector calculus and its applications in particular fluid dynamics and electromagnetism. The module consists of two parts, which are closely linked. In the first part of the module, you will learn about the mathematical theory and techniques of vector calculus. You will develop your competence in using vector calculus in both differential and integral forms. The second part of the module gives an introduction to fluid dynamics and electromagnetism as two applications of vector calculus. It lays down some basic principles using a number of simplifying assumptions.

This module is a prerequisite for several specialist modules in the third year and fourth year, including MTH3007 Fluid Dynamics (which develops theory for flow with viscosity), MTH3008 Partial Differential Equations, MTH3001 Theory of Weather and Climate, MTHM031 Magnetic Fields and Fluid Flows and MTHM045 Space Weather and Plasmas.
Prerequisite modules: MTH1002 or NSC1002 or equivalent

AIMS - intentions of the module

This introductory vector calculus course aims to increase your understanding of fluid dynamics and electromagnetism. It examines how one can use vector formalism and calculus together to describe and solve many problems in two and three dimensions. For example, the rules that govern the flow of fluids can be described using vector calculus, with resulting laws of motion described by partial differential equations rather than ordinary differential equations.

INTENDED LEARNING OUTCOMES (ILOs) (see assessment section below for how ILOs will be assessed)

On successful completion of this module ***you should be able to***:
Module Specific Skills and Knowledge
1. define and express vector calculus notation;
2. carry out manipulations with vector calculus in both differential and integral forms (line, surface and volume integrals);
3. implement and illustrate the application of vector calculus to problems in inviscid fluid mechanics and electromagnetism.

Discipline Specific Skills and Knowledge
4. validate a number of mathematical modelling techniques with application to fluid dynamics and electromagnetism.

Personal and Key Transferable / Employment Skills and Knowledge
5. devise how to formulate and solve complex problems.

SYLLABUS PLAN - summary of the structure and academic content of the module

summation convention;
definitions of scalar field, level surface, vector fields, field lines;
motivation from fluid flow;
vector differentiation and the differential operators: gradient, divergence, and curl;
examples in 3D for Cartesian, cylindrical and spherical coordinates;
line integrals and elementary surface and volume integrals;
Stokes' theorem and the divergence theorem;
introduction to continuum mechanics and Eulerian fluid mechanics;
velocity, acceleration, streamlines and pathlines;
the continuity equation and incompressibility;
vorticity and circulation;
pressure, constitutive equations, Euler's equations, steady and unsteady flows;
irrotational and rotational motion;
velocity potential for irrotational motion;
Bernoulli's equation;
Streamlines, Vortex lines and the Stream Function;
Charge conservation
Maxwell’s equations
Electromagnetic potentials

LEARNING AND TEACHING

LEARNING ACTIVITIES AND TEACHING METHODS (given in hours of study time)

Scheduled Learning & Teaching Activities	33.00	**Guided Independent Study**	118.00	**Placement / Study Abroad**	

DETAILS OF LEARNING ACTIVITIES AND TEACHING METHODS

Category	Hours of study time	Description
Scheduled learning and teaching	33	Lectures including examples classes
Scheduled learning and teaching activities	5	Tutorials
Guided independent study	112	Lecture and assessment preparation; wider reading

ASSESSMENT

FORMATIVE ASSESSMENT - for feedback and development purposes; does not count towards module grade

Form of Assessment	Size of Assessment (e.g. duration/length)	ILOs Assessed	Feedback Method
Exercise sheets	5 x 10 hours	1, 2, 3, 4, 5	Written/ oral feedback in tutorial classes and drop-ins; written/oral feedback on submitted solutions.
Online Quizzes	3x (8-30) min	1,2	Written/oral feedback online and in class.

SUMMATIVE ASSESSMENT (% of credit)

Coursework	20	**Written Exams**	80	**Practical Exams**	

DETAILS OF SUMMATIVE ASSESSMENT

Form of Assessment	% of Credit	Size of Assessment (e.g. duration/length)	ILOs Assessed	Feedback Method
Written exam – closed book	80	2 hours	1, 2, 3, 4	Written/verbal on request, SRS.
Coursework 1	10	10 hours	1, 2	Annotated script and written/verbal feedback online and in class
Coursework 2	10	10 hours	1, 2, 3, 4, 5	Annotated script and written/verbal feedback online and in class

DETAILS OF RE-ASSESSMENT (where required by referral or deferral)

Original Form of Assessment	Form of Re-assessment	ILOs Re-assessed	Time Scale for Re-reassessment
All above	Written exam (100%)	1, 2, 3, 4	August Ref/Def period

RE-ASSESSMENT NOTES

Deferrals: Reassessment will be by coursework and/or exam in the deferred element only. For deferred candidates, the module mark will be uncapped.

Referrals: Reassessment will be by a single written exam worth 100% of the module only. As it is a referral, the mark will be capped at 40%.

RESOURCES

INDICATIVE LEARNING RESOURCES - The following list is offered as an indication of the type & level of information that you are expected to consult. Further guidance will be provided by the Module Convener

ELE – http://vle.exeter.ac.uk

Reading list for this module:

Type	Author	Title	Edition	Publisher	Year	ISBN	Search
Set	Finney, R.L., Maurice, D., Weir, M. and Giordano, F.R.	Thomas' Calculus based on the original work by George B. Thomas, Jr.	10th or later	Addison-Wesley	2003	000-0-321-11636-4	[Library]
Set	Arfken, G.B. & Weber, H.J.	Mathematical Methods for Physicists	Electronic	Harcourt/ Academic Press	2005	000-0-120-59825-6	[Library]
Set	Acheson, D.J.	Elementary Fluid Dynamics		Clarendon Press	1990	978-0-198-59679-0	[Library]
Set	Tritton D.J.	Physical Fluid Dynamics	2nd	Clarendon Press, Oxford	1988	000-0-198-54493-6	[Library]
Set	Batchelor G.K.	An Introduction to Fluid Dynamics		Cambridge University Press	1999	000-0-521-04118-X	[Library]
Set	Matthews P.C	Vector Calculus	1st	Springer	1998	978-3540761808	[Library]
Set	Spiegel M.R., Lipschutz S., Spellman D.	Vector Analysis and an Introduction to Tensor Analysis	2nd	McGraw-Hill	2009	9780071615457	[Library]
Set	Paterson A.R.	A first course in fluid dynamics	Electronic	Cambridge University Press	1983	9780521274241	[Library]
Set	Nahvi, M; Edminister, J	Schaum's Outline of Electromagnetics	5th	McGraw-Hill Education	2019	9781260120974	[Library]

CREDIT VALUE	15	**ECTS VALUE**	7.5
PRE-REQUISITE MODULES	MTH1002		
CO-REQUISITE MODULES			
NQF LEVEL (FHEQ)	5	**AVAILABLE AS DISTANCE LEARNING**	No
ORIGIN DATE	Tuesday 10 July 2018	**LAST REVISION DATE**	Tuesday 26 September 2023
KEY WORDS SEARCH	Vector calculus; differential operators; line, surface and volume integrals; integral theorems; curvilinear coordinates; inviscid fluid dynamics; electromagnetism		