

MODULE TITLE	Magnetic Fields and Fluid Flows	CREDIT VALUE	15
MODULE CODE	ECMM731	MODULE CONVENER	Dr Joanne Mason (Coordinator)
DURATION: TERM	1	2	3
DURATION: WEEKS	11		

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# Number of Students Taking Module (anticipated)

### **DESCRIPTION - summary of the module content**

This module deals with the motion of electrically conducting fluids in the presence of magnetic fields, a subject known as magnetohydrodynamics (MHD). MHD flows play a crucial role in the dynamics of a variety of astrophysical systems (including stars, planets, accretion discs and galaxies). MHD flows are also studied in the laboratory with a view towards engineering applications (e.g. electromagnetic stirring and fusion plasmas). In this module you will see how the mutual interaction of the fluid flow and the electromagnetic field reveals a variety of new and interesting phenomena. You will learn how to formulate a real physical problem in terms of a system of partial differential equations. We will solve these using a variety of techniques of applied mathematics.

#### Prerequisite module: ECM3707 or equivalent

#### AIMS - intentions of the module

The aim of this module is to give you an introduction to the subject of electrically conducting fluid dynamics.

This module can be seen as an extension of the third year module ECM3707 on viscous fluids. You will learn how the equations of fluid dynamics are modified when electromagnetic effects are taken in account. The mathematical theory will be illustrated with examples from astrophysics, geophysics and laboratory plasma physics.

#### 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 the concepts and equations governing the interaction of magnetic fields and electrically conducting flows;

2 prove some important theorems and analyse the solutions of the MHD equations using a variety of techniques of applied mathematics.

Discipline Specific Skills and Knowledge:

3 formulate a real physical problem mathematically;

4 explain mathematical solutions in terms of physical effects. Personal and Key Transferable / Employment Skills and Knowledge:

5 develop communication skills via in class discussions;

6 practice time management skills in order to meet coursework deadlines.

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

#### Fundamentals and simple examples:

- motivation for studying magnetic fields and fluid flow;

- a brief introduction to electrodynamics: Maxwell's equations;
- the equations of electrically conducting fluid dynamics;
  the MHD approximation:

- basic properties of the induction equation, including the diffusive limit, the perfectly conducting limit and Alfvén's theorem of flux freezing.

#### Magnetohydrostatics and steady MHD flows:

- force-free fields, including potential fields and field-parallel currents;
- pressure balanced configurations and plasma confinement;
- steady unidirectional flow (hydromagnetic Poiseuille and Couette flow).

#### MHD waves:

- Alfvén waves in an infinite, inviscid, incompressible fluid of infinite electrical conductivity;
- phase velocity and group velocity;
- damped Alfvén waves.

#### An introduction to dynamo theory:

- observational evidence for astrophysical magnetic fields;
- formulation of the kinematic dynamo problem;
- poloidal and toroidal fields;
- antidynamo theorems;
- qualitative picture of large-scale dynamo action, involving differential rotation and helical turbulence;
- mean-field electrodynamics;
- Parker's dynamo waves.

# LEARNING AND TEACHING

LEARNING ACTIVITIES AND TEACHING METHODS (given in hours of study time)							
Scheduled Learning & Teaching Activities	33.00	Guided Independent Study	117.00	Placement / Study Abroad	0.00		
DETAILS OF LEARNING ACTIVITIES AND TEACHI	NG METH	IODS					
Category		Hours of study time	Descrip	tion			
Scheduled learning and teaching activities		27	Lecture	s			
Scheduled learning and teaching activities		6	Example	es classes			
Guided independent study		30	Problen	n sheets			
Guided independent study		87	Reading	, revision, preparation			

# 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
Problem sheets containing a mixture of short answer questions and more comprehensive exercises $\label{eq:problem}$	5 hours/4 questions per problem sheet (6 sheets)	1-6	Examples class, solutions and general comments uploaded to ELE

SUMMATIVE ASSESSMENT (% of credit)								
Coursework	0 Writ	ten Exams	100	Practical Exams		0		
DETAILS OF SUMMATIVE ASSESSMENT								
Form of Assessment	% of Credit	Size of Assessment (e.g. duration/le	ngth)	ILOs Assessed	Feedback Method			
Written exam - closed book	100	2 hours		1-4	Oral on request			

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-assessment				
All	Written exam (100%)	All	August Ref/Def period				

## **RE-ASSESSMENT NOTES**

Referred and deferred assessment will be by examination. For referrals, only the examination will count, a mark of 40% being awarded if the examination is passed. For deferrals, candidates will be awarded the higher of the deferred examination mark or the deferred examination mark combined with the original coursework mark.

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:

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Туре	Author	Title	Edition	Publisher	Year	ISBN	Search
Set Set	Roberts P.H. Choudhuri, A.R Ferraro, V.C.A.& Plumpton	An Introduction to Magnetohydrodynamics The Physics of Fluids and Plasmas	Forum Library 538.6 ROB Forum Library 530.4 CHO	Longman Cambridge Universi	1967 ty Press 1998	0582447283 0521555434	[Library] [Library]
Set	C	An Introduction to Magneto-Fluid Mechanics	s Forum Library 538.6 FER	Oxford University Pr	ess 1966	0198531311	[Library]
Set	Priest, E	Solar Magnetohydrodynamics	Forum Library 523.7 PRI	D. Reidel publishing	company1982	902771374X	[Library]
CRED	IT VALUE	15 E	CTS VALUE	7.5			
PRE-F	EQUISITE MODULES	ECM3707					
CO-R	EQUISITE MODULES						
NQF L	EVEL (FHEQ)	7	AVAILABLE AS DISTA	NCE LEARNING NO	D		
ORIG	N DATE	Friday 09 January 2015	LAST REVISION DATE	E Fr	iday 09 January	2015	
KEY V	VORDS SEARCH	Fluid dynamics; magnetic fields; MHD;	applications of vector cale	culus.			