MODULE TITLE	**Applied Differential Geometry**	**CREDIT VALUE**	**15**
MODULE CODE	**MTH3013**	**MODULE CONVENER**	**Dr Hamid Alemi Ardakani (Coordinator)**

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

Number of Students Taking Module (anticipated)	**25**

DESCRIPTION - summary of the module content

On this module, you will have the opportunity to study mathematical topics involving differential geometry of curves and surfaces, and calculus on manifolds. You will learn about various topics in differential geometry such as curves in space and curvature, manifolds and coordinate charts, classification of surfaces, the fundamental equations of surfaces, Gaussian and mean curvatures, and the Gauss-Bonnet theorem. You become familiar with differential forms, integration and differentiation of differential forms, and the generalised Stokes' theorem. Furthermore, you will learn about formalism of tensors. This includes covariant and contravariant tensors, tensor fields, elementary operations with tensors, the Lie derivative, the affine connection and covariant differentiation, geodesic coordinates, the metric, and the curvature tensor, as well as the Euler–Lagrange equations and variational methods for geodesics.

Pre-requisite modules: MTH2004 Vector Calculus and Applications, MTH2003 Differential Equations, or equivalent

AIMS - intentions of the module

The module aims to develop students' knowledge of differential geometry of curves and surfaces. By taking it, you will gain a better understanding of manifolds, their mathematical description, and calculus on manifolds. Furthermore, the module provides an introduction to differential forms from a geometric viewpoint. By learning advanced topics in tensor calculus, the module aims to provide a solid foundation for the theory of General Relativity.

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. Demonstrate a working knowledge of the mathematical representation of curves and surfaces.
2. Calculate curvature, prove and verify the local and global versions of the Gauss–Bonnet theorem.
3. Demonstrate a working knowledge of differential forms, the generalised Stokes' theorem, calculus on manifolds, and geodesics

Discipline Specific Skills and Knowledge

4. Reveal an understanding of the fundamental concepts of the differential geometry of curves and surfaces, differential forms and tensor calculus, and appreciate their relevance to many areas of mathematics.

Personal and Key Transferable / Employment Skills and Knowledge

5. Display enhanced theoretical and analytical skills in geometry and advanced calculus, and show competence in modelling geometric objects in computer graphics.
6. Display enhanced problem-solving skills.
7. Demonstrate self-management and time management skills.

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

Topics will include some or all of:

Geometry of Curves in Space: curvature, torsion, the Frenet–Serret frame, osculating plane and osculating sphere.

Manifolds and Geometry of Surfaces: manifolds and coordinate charts, transformation of coordinates, parameterised surfaces, the first and second fundamental forms, Gaussian and mean curvatures, minimal surfaces, Gauss' equations and the Christoffel symbols, Weingarten and Codazzi equations, the theorem Egregium, the Gauss–Bonnet theorem and geometry of geodesics.

Differential Forms: families of forms, integrating differential 2-forms, the generalised Stokes' theorem, the Gauss-Bonnet theorem from differential forms perspective.

Tensor Algebra and Tensor Calculus: contravariant tensors, covariant and mixed tensors, tensor fields, elementary operations with tensors, partial derivative of a tensor, the Lie derivative, the Riemann tensor, geodesic coordinates, the metric and metric geodesics, the metric connection and the curvature and Weyl tensors, tensor densities, the metric determinant, Stokes' theorem, and the Euler Lagrange equations and variational methods for geodesics.

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**	

DETAILS OF LEARNING ACTIVITIES AND TEACHING METHODS

Category	Hours of study time	Description
Scheduled Learning and Teaching Activities	33	Lectures (33 hours) Extensive notes and exercises are provided.
Guided independent study	117	Coursework preparation; private study

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
Un-assessed coursework is assigned to the students, and a sketch of solutions to these are provided.	3 hours per week	All	Written and verbal feedback is provided during lectures and office hours.

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
Coursework 1 – assessed problem sheet	10	15 hours	All	Annotated script and written/verbal feedback
Coursework 2 – assessed problem sheet	10	15 hours	All	Annotated script and written/verbal feedback
Written Exam – Closed Boo	80	2 hours	All	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 above	Written Exam (100%)	All	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

Reading list for this module:

Type	Author	Title	Edition	Publisher	Year	ISBN	Search
Set	Bachman, D.	A Geometric Approach to Differential Forms		Springer Science & Business Media	2012		[Library]
Set	D'Inverno, R.	Introducing Einsteinâ€™s Relativity		Oxford University Press	1992		[Library]
Set	do Carmo, M. P.	Differential Geometry of Curves and Surfaces		Prentice-Hall	1976		[Library]
Set	Pressley, A. D.	Elementary Differential Geometry		Springer	2010		[Library]

CREDIT VALUE	15	**ECTS VALUE**	7.5
PRE-REQUISITE MODULES	MTH2003, MTH2004		
CO-REQUISITE MODULES			
NQF LEVEL (FHEQ)	6	**AVAILABLE AS DISTANCE LEARNING**	No
ORIGIN DATE	Tuesday 17 January 2023	**LAST REVISION DATE**	Tuesday 26 September 2023
KEY WORDS SEARCH	Differential Geometry, Differential Forms, Tensor Calculus		