Subject Information Guide

Differential Geometry (Research Topics in Mathematics 1 - MATH704)

Semester 2, 2018

Administration and contact details

Host Department	Department of Mathematics
Host Institution	Macquarie University
Name of lecturer	Paul Bryan
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Subject details

Handbook entry URL	http://www.handbook.mq.edu.au/2018/Units/ResearchUnit/MATH704
Subject homepage URL	
Honours student hand-out URL	
Start date:	30 July 2018
End date:	2 November 2018
Contact hours per week:	2 hours
Lecture day and time:	TBA
Description of electronic access arrangements for students (for example, WebCT)	Materials will be made available on lecturer's website.

Subject content

1. Subject content description

Differential geometry is the analysis and geometry of spaces that may have curvature. For example, calculus may be formulated on the surface of the sphere, as can notions of length, angle and area. Moreover, such a theory, as initiated by Gauss and Riemann, then developed

by many in the late 19th century and throughout the 20th century, need not assume the sphere is embedded inside any ambient space. Rather, the theory can be developed and applied to the geometry, and in particular the curvature of space itself. This is the foundation of Einstein's General Theory of Relativity.

2. Week-by-week topic overview

The following content will be distributed over the 12 week semester.

- **Introduction:**
  Euclidean geometry, the parallel postulate and non-Euclidean geometry.
- **Curves:**
  Classic theory of curves. Curvature, torsion, Frenet-Serret frame. Global results such as 4-vertex theorem.
- **Surfaces:**
  Surfaces in three-dimensional Euclidean space. Local parametrisations, change of coordinates, differential calculus. Geometry (length, angle area) of surfaces.
- **Curvature of Surfaces:**
  The second fundamental form (extrinsic curvature). Principal, mean and Gauss curvatures.
- **Intrinsic Geometry:**
  Manifolds and Riemann geometry. Metrics, covariant derivatives and curvature. The Gauss Theorema Egregium. Gauss-Bonnet Theorem.

3. Assumed prerequisite knowledge and capabilities

Linear algebra. Vector calculus and multi-variable calculus.

4. Learning outcomes and objectives

At the end of the subject, students will be able to study modern differential geometry, topology and the variety of applications such as in General Relativity.

AQF specific Program Learning Outcomes and Learning Outcome Descriptors (if available):

AQF Program Learning Outcomes addressed in this subject	Associated AQF Learning Outcome Descriptors for this subject
K1	coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines
K2	knowledge of research principles and methods

S1	cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence
S2	cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas
S3	cognitive skills to exercise critical thinking and judgement in developing new understanding
S4	technical skills to design and use in a research project
A2	to adapt knowledge and skills in diverse contexts

Learning Outcome Descriptors at AQF Level 8

Knowledge

K1: coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines

K2: knowledge of research principles and methods

Skills

S1: cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence

S2: cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas

S3: cognitive skills to exercise critical thinking and judgement in developing new understanding

S4: technical skills to design and use in a research project

S5: communication skills to present clear and coherent exposition of knowledge and ideas to a variety of audiences

Application of Knowledge and Skills

A1: with initiative and judgement in professional practice and/or scholarship

A2: to adapt knowledge and skills in diverse contexts

A3: with responsibility and accountability for own learning and practice and in collaboration with others within broad parameters

A4: to plan and execute project work and/or a piece of research and scholarship with some independence

5. Learning resources

Written lectures notes will be available for students and will be uploaded to the unit website. The following references may prove useful.

References:

a. *Differential geometry of curves and surfaces*, Manfredo do Carmo, Prentice-Hall (1976).
b. Curves and Surfaces, Sebastián Montiel and Antonio Ros, AMS (2009).
c. Elementary Differential Geometry, Christian Bär, Cambridge University Press (2010).

d. *Differential Topology,* Victor Guillemin and Alan Pollack, AMS (1974).
e. *Riemannian Geometry*, Manfredo do Carmo, Prentice-Hall (1976).
f. Introduction to smooth manifolds, John Lee, Spinger Verlag (2003).
g. Riemannian Manifolds – An Introduction To Curvature, John Lee, Spinger Verlag (1997)

6. Assessment

Exam/assignment/classwork breakdown					
Exam	60 %	**Assignment**	40 %	**Class work**	Enter %
Assignment due dates		TBA	TBA		
Approximate exam date				Week following end of lectures (TBA)	

Institution Honours program details

Weight of subject in total honours assessment at host department	12.5% of BPhil
Thesis/subject split at host department	BPhil has no thesis; thesis is 90% of MRes
Honours grade ranges at host department:	
H1	85%
H2a	75%
H2b	65%
H3	50%