MATH0025 (Mathematics for General Relativity)

Year:	2019–2020
Code:	MATH0025
Old code:	MATH3305(UG)/MATHG305(PG)
Level:	6(UG)/7(PG)
Normal student group(s):	UG: Year 3 Maths degrees and Year 3 Physics degrees PG: MSc Physics
Value:	15 credits (= 7.5 ECTS credits)
Term:	1
Structure:	3 hour lectures per week. Weekly assessed coursework.
Pre-requisite:	MATH0016 (was MATH2401) for Mathematics students MATH0043 (was MATH6202) for UG Physics students.
Assessment:	90% examination, 10% coursework
Lecturer:	Dr C Boehmer

Course Description and Objectives

The course introduces Einsteins theory of general relativity. General relativity, introduced in the early 20th century, along with quantum field theory, provides the modern framework for the description of the fundamental physical theories of gravity and electromagnetism. Special relativity deals with physics in the absence of gravity. It requires a rethink of many familiar concepts (such as what it means for events to be simultaneous) because of the constancy (and finiteness) of the speed light. We will briefly be looking at the basic physical concepts of mass, momentum, energy and electromagnetism within this framework and their mathematical description. No prior familiarity of Maxwells equations will be assumed.

General relativity is a profound generalisation of special relativity which incorporates gravity. The mathematical description of general relativity requires the mathematical language of differential geometry which uses the notions of metric, connection and curvature, which will be introduced from scratch. The earliest tests of general relativity where the observation that light is bent by massive objects such as the sun, the precession of the perihelion of the planet Mercury, gravitational red-shifts and radar echo delays. The recently observed gravitational waves are a simple consequence of the field equations. Some of these will be discussed at the end of the course.

Recommended Texts

(i) C. G. Boehmer, *"Introduction to General Relativity and Cosmology"*, World Scientific in press.

(ii) R. M. Wald, *"General Relativity"*, University of Chicago Press.

(iii) B. F. Schutz, *"A first course in general relativity"*, Cambridge University Press.

(iv) L. P. Hughston and K. P. Tod, *"An Introduction to General Relativity"*, LMS Student Texts 5, 1990, Chapters 1-18.

(v) N. M. J. Woodhouse, *"General Relativity"*, Springer.

Detailed Syllabus

- Vectors and gradients.
- Manifolds and tensors.
- Metrics.
- Geodesics.
- Curvature
- Some physics background.
- Geometry and gravity.
- Einstein field equations.
- Schwarzschild solutions.
- Classical tests.