

3305 (Mathematics for General Relativity)

<i>Year:</i>	2014–2015
<i>Code:</i>	MATH3305
<i>Level:</i>	Advanced
<i>Value:</i>	Half unit (= 7.5 ECTS credits)
<i>Term:</i>	1
<i>Structure:</i>	3 hour lectures per week. Weekly assessed coursework.
<i>Assessment:</i>	90% examination, 10% coursework
<i>Normal Pre-requisites:</i>	MATH2401 (Mathematicians), MATH6202 (Physicists)
<i>Lecturer:</i>	Prof M Singer

Course Description and Objectives

The course introduces Einstein's theories of special and general relativity. These theories, introduced in the early 20th century, along with quantum theory, provide 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 of light. We will be looking at the basic physical concepts of mass, momentum, energy and electromagnetism within this framework and their mathematical description. No prior familiarity of Maxwell's equations will be assumed.

General relativity is a profound generalisation of special relativity which incorporates gravity. The mathematical description of general relativity requires the notions of metric, connection and curvature, which will be introduced from scratch.

The earliest tests of general relativity were the observation that light is bent by massive objects such as the sun and the precession of the perihelion of the planet Mercury. These will be discussed at the end of the course.

Recommended Texts

- (i) N. Woodhouse, "*Special Relativity*", Springer UTM.
- (ii) L. P. Hughston and K. P. Tod, "*An Introduction to General Relativity*", LMS Student Texts 5, 1990, Chapters 1-18.

Detailed Syllabus

- Vectors and gradients.
- Curved surfaces and spaces.
- Metrics.
- Tensor notation.
- Electromagnetism in tensor notation.
- The principle of equivalence.

- Geodesics and the motion of objects in a curved space.
- The deflection of starlight by the sun. The precession of Mercury.
- Einstein field equations.

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