PH5011 - General Relativity

Overview
The module starts with an introduction to Einstein's theory of General Relativity, which Arthur Eddington called "a most profound theory of Nature, embracing almost all the phenomena of physics". We then establish the link between gravity and space-time curvature from fundamental principles, and then derive predictions of several deviations from the earlier theory of gravity by Newton, most prominently in the bending of light by massive objects, which are now well-confirmed by respective observations. Besides the fundamental physical concepts, fairly advanced mathematics of curved space is an essential part of quantitative understanding of applications of General Relativity. A main example of astronomical application is the motion of particles and photons inside the Schwarzschild's solution of Einstein's field equations for a static spherically-symmetric massive body. Not only is General Relativity as a tool for astronomy addressed, but moreover a look is given to its role in technology.

Aims & Objectives
The module should provide an introduction and applications to the theory of General Relativity, covering the following topics:

- the “need” for General Relativity and its historic evolution - fundamental principles of General Relativity
- the advanced mathematics required in order to apply the theory - derived predictions and their experimental tests
- application of general relativity in science and technology

Learning Outcomes
Students are expected to be able to

- understand the fundamental concepts of the theory of General Relativity
- practice tensor analysis to describe physical phenomena in curved space-time - derive the equations of motion from a given metric tensor
- compute the general-relativistic effects relevant to astronomy
- compute the effects of general relativity in modern technology

Synopsis
Motivation and history of General Relativity
Fundamental concepts
Covariant derivatives and tensor analysis in curved space
Einstein's field equations and Schwarzschild solution
Newtonian limit
Equations of motion from Lagrangian formalism
Predictions and observations
General Relativity applications in lensing and astronomy
General Relativity in GPS technology

Pre-requisites
PH3081 or PH3082 or (MT2003 or [MT2506 and MT2507]). Recommended PH4038 and PH4032.

Anti-requisites
None

Assessment
2 Hour Examination = 100%
Recommended Books
Please view University online record: http://resourcelists.st-andrews.ac.uk/modules/ph5011.html

General Information
Please also read the general information in the School's honours handbook.