First course handout for PHY-407
(Special and General Relativity)

Instructor: Kaushik Bhattacharya
Department of Physics, IIT Kanpur
Email: kaushikb@iitk.ac.in

Motivation: Special Theory of Relativity (STR) and General Theory of Relativity (GTR) are the pillars of modern physics. While STR dictates most of the relevant physics at the microscale and astrophysical scales, GTR dictates most of the physics at astronomical and cosmological scales. In the present course we will try to start with a general curved spacetime and formulate the basics of such spacetimes. It will lead to the premises of GTR. It will be seen that STR is a special case, where the curvature of spacetime vanishes. STR and its effects will be understood as some limiting cases of GTR. Throughout the course emphasize will be on general relativistic intuition.

Outline of the course: The course will start with a general introduction of curved spacetime. The concepts of affine connection, geodesics and curvature will be introduced initially. Then we will show the properties of flat spacetime and introduce the concepts of STR. The Principle of Equivalence will play a very important role in our discussion.

After the initial phase we will try to motivate the Einstein equation in GTR. The course will not focus on action principle. Einstein equation will be introduced intuitively and phenomenologically.

The last part of the course will give various solutions to the Einstein equation. We will particularly discuss the Schwarzschild Black Hole solution and the FriedmannLemaitre-Robertson-Walker (FLRW) cosmological solution of the Einstein equation.

Non-class contact with instructor: There will be a tutor for this course. You can contact him for some questions via email. The students can always email the instructor about their questions. Depending upon the gravity of the question the instructor will decide how the question can be answered. If the answer requires deep conversation then instructor will ask the student to meet in the office.

Grading rules: Primarily there will be two examinations and one or two quizzes for this course. The quiz dates will be determined once the course starts. There will be regular homeworks given. Some of the homeworks will be graded. The midsemester examination will be out of 80 marks. The end-semester examination will

be out of 100 marks. 20 marks will be allotted for quizzes and homeworks. All the examination and quizzes will have equal strength in final grading, none of these examinations are more sacrosanct. If someone does not appear for the end-sem examination he/she will fail the course.

Prerequisites: All students who will credit this course must have done a at least one course in special relativity. Moreover people who have know tensor analysis are preferred.

Reference:

1. Classical Theory of Fields by Landau and Lifshitz.
2. Gravity: An introduction to Einstein's Relativity by James B. Hartle.
3. Gravitation and Cosmology by Steven Weinberg.

One may consult any of the above books. In general the student may read any material which he/she finds suitable to follow the class material.

On class attendance: All students are expected to do all the classes of these course. Biometric attendance will be taken. Students who fail to appear in class for consecutive four days will be penalized and if this practice goes on respective students will be deregistered from the course.