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General Relativity in the Undergraduate Physics Curriculum

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Einstein's theory of gravitation — general relativity— will shortly be a century old. At is core is one of the most beautiful and revolutionary conceptions of modern science — the idea that gravity is the geometry of four-dimensional curved spacetime. Together with quantum theory, general relativity is one of the two most profound developments of twentieth century physics. General relativity underlies our understanding of the universe on the largest distance scales, and is central to the the explanation of such frontier astrophysical phenomena gravitational collapse,black holes, X-ray sources, neutron stars, active galactic nuclei, gravitational waves, and the big bang. General relativity is the intellectual origin of many ideas in contemporary elementary particle physics such as string theory. This talk will make the case that an introduction to general relativity is naturally a part education of every undergraduate physics major, and describe a 'physics first' approach to teaching at that level. The simplest physically relevant solutions of the Einstein equation, such as those representing black holes, simple cosmologies, and gravitational waves, are presented first without derivation. Their observational consequences are explored by the study of the motion of test particles and light rays in them.This brings the student to the physical phenomena as quickly aspossible. It is the part of the subject most directly connectedto classical mechanics, and requires the minimum of new mathematical ideas. The Einstein equation is introduced later to show where these geometries originate. A course for junior or senior level physics students based on theseprinciples has been part of the undergraduate curriculum at the University of California, Santa Barbara for several decades. It works.