Certificate Course on
A Tensorial Way to Relativity & Cosmology

Course Type: Online Certificate Course (It's free, no Course Fee required)
Certificate Issuing Authority: Banwarilal Bhalotia College, Asansol, West Bengal, India
Course Organizer: Department of Mathematics, Banwarilal Bhalotia College, Asansol
Under the Aegis of IQAC, Banwarilal Bhalotia College, Asansol
Target Audience: UG/PG Level Mathematics and Physics Students
Pre-Requisites: Basic Knowledge on Geometry, Differential Calculus & Vectors
Course Opening Date: 17th October, 2021 (Tentative)
Course Registration: Register on/before 10th October, 2021 through the following link
https://forms.gle/dfQo3E9HtNfsxAEw5
Course Duration: 12 Weeks (Approx. 3 Classes per Week, Each of 1 Hour Duration)
Course Mode: Virtual/Online through Google Meet Platform
Class Timings: All the Classes will be Scheduled in the Evening between 7 PM – 9 PM (IST)
Course Exams: Regular Weekly Assignments & Final Exam at the end of the Course
Course Instructor: Dr. Sudipta Das, Assistant Professor in Department of Mathematics
Banwarilal Bhalotia College, Asansol - 713303, West Bengal, India
Email id: sudipta_jumaths@yahoo.co.in

Course Outline & Outcome:

This course is specifically designed for advanced UG and PG level students in Mathematics and Physics. We will start with the basic idea of tensors as a generalization of vectors. We will then gradually move on to learn the details of algebraic operations on the tensors along with the transformation laws. Then we will proceed to the core topic of tensor calculus and study the ideas like metric tensors, curvature and derivatives of tensors with adequate examples. Finally, we will delve deeper into the course where the applications of tensor calculus in different fields of Physics, especially in Special & General Theory of Relativity and Cosmology will be discussed in details with some elaborate demonstrations. This course will enable the students to learn about the modern-day research topics such as Relativity and Cosmology and to acquire the necessary tools which will surely help them in their future fields of research. Certificates will be issued at the end of the Course to the successful participants.

Course Syllabus/Modules

Week 1 & 2 (Module – 1): Basics of Tensors & Tensor Algebra (5-6 Classes)
Vectors, Euclidean & non-Euclidean Geometry, notations about indices & summation convention, symmetric & anti-symmetric systems, tensors as generalization of vectors, transformation properties of tensors: contravariant, covariant & mixed tensors, algebraic operations on tensors: contraction, inner product & outer product of tensors, idea of metric tensor and its applications. ***Assignments at the end of each week.***

Week 3, 4 & 5 (Module – 2): Introduction to Tensors Calculus (8 Classes)
Differentiation of tensors: covariant derivative, definition and properties of affine connection & Christoffel symbols, differential operators & their properties: gradient, curl, divergence & Laplacian, Lagrangian & geodesic equations, definition & properties of Riemann curvature tensor, Ricci tensor & Ricci scalar. ***Assignments at the end of each week.***

Week 6, 7 & 8 (Module – 3): Tensorial Description of Special Theory of Relativity (9-10 Classes)

4-dimensional Minkowski Spacetime & four-vectors, Principles of Relativity, interval between two events, Lorentz transformations: time dilation & length contraction, velocity & acceleration four-vectors, energy-momentum four-vector, angular momentum tensor, relativistic dynamics: covariant Newton's law, covariant laws of electromagnetism. ***Assignments at the end of each week.***

Week 9, 10, 11 & 12 (Module – 4): Applications to General Relativity & Cosmology (12 Classes)

Action integral, electromagnetic field equations, action for matter fields, Einstein tensor, Introduction to Theory of General Relativity, Einstein field equations, Black Holes: Schwarzschild solution, introduction to Cosmology: Robertson-Walker metric, Friedmann equations, solutions to Friedmann equations and models of our Universe, distance measurements, cosmological redshift, Hubble law and expanding universe, Basic idea of Cosmic Microwave Background Radiation (CMBR). ***Assignments at the end of each week.***

Course Materials/Reference Books:

Basic Texts:

1. Tensors, Relativity and Cosmology by Mirjana Dalarsson & Nils Dalarsson, Academic Press.
2. Introducing Einstein's Relativity by Ray D'Inverno, Oxford University Press.
3. Spacetime and Geometry by Sean M. Carroll, Addison Wesley.

For Further Reading:

4. Lecture Notes on General Relativity by Matthias Blau.
http://www.blau.itp.unibe.ch/GRLecturenotes.html
5. Relativity, Gravitation and Cosmology by Robert J. A. Lambourne, Cambridge Publishers.

About Course Instructor:

Dr. Sudipta Das has joined at Banwarilal Bhalotia College, Asansol on 25th February, 2015 as an Assistant Professor in Mathematics and working here till date. He has completed his Ph.D. from Indian Statistical Institute, Kolkata on 7th January, 2015. His specialization is in Mathematical Physics and his research interest lies in the fields of Relativity and Cosmology, especially on the topic of Dark Energy in Cosmology. Presently he is offering numerous UG Courses for B.Sc. Mathematics Hons. students on Differential Calculus & Differential Equations, Calculus of Several Variables, Particle Dynamics, Dynamics of Rigid Bodies, Probability & Statistics, Special Theory of relativity; and one PG Course for M.Sc. Physics students on Special Theory of Relativity. An avid reader and traveller, whenever not busy with teaching jobs or research works, Dr. Das can often be found to be travelling in the Himalayas.