PHYS 458: Special and General Relativity

To your attention: "The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particular misrepresentation of facts and/or participation in an offense. Academic dishonesty is a serious offense and can result in suspension or expulsion from the University." (GFC 29 SEP 2003)

Instructor Dmitri Pogosian

Office:	Room 2-105 CCIS-Physics
Office Hours:	by appointment (i.e - drop by !)
e-mail:	pogosyan@phys.ualberta.ca
WWW:	`www.ualberta.ca/~pogosyan`
Phone:	492-2150

Time and Place: Mon, Wed 2 pm - 3.20 pm, CCIS L1-029

Calendar Description: Special Relativity: space-time, Lorentz transformations, definition of scalars, vectors and tensors, motion of a relativistic particle, energy-momentum tensor and equations of motion. General Relativity: geometry of curved space-time, equivalence principle, gravity as curvature, Einstein equations, black hole and cosmological solutions, gravitational waves.

Texts :

Main: M. P. Hobson, G. Efstathiou and A.N. Lasenby General Relativity, Cambridge University Press, 2006, QC 173.6 H63 2006. Chapters (parts of): 1-5, 7-9, time permitting: 14, 18

Additional:
David J. Griffiths, Introduction to Electrodynamics, 3rd Edition, Chapter 12 (Special Relativity), Prentice-Hall, 1999, QC680 G855 1999.
Landau, L. D. and Lifshitz, E. M. The classical Theory of Fields, Oxford Pergamon Press, 1975. QC 670 L25 1975

Marking Scheme

Assignments:	36% (6 assignments 6%)
Midterm Test:	20% (end of October)
Final Exam:	44 % (December)

Approximate content - to be adjusted as the course proceeds:

Part I: Special Relativity – 8 lectures.

- Galilean relativity - invariance of physical laws under Galilean transformations. Separate treatment of space and time - invariant notions of 3D distance (thus 3D vectors) and time intervals. Relation of homogeneity and isotropy of 3D space to the mechanical laws of free particle motion (Lagrangian of free particle)
- Special Relativity. Space-time concept in the presence of the maximal velocity. Events, 4 vectors, tensors, Lorentz transformations, invariant distance in 4D Minkowski space-time.
- Geometrical nature of relativistic free particle motion. 4-velocity.
- Classical relativistic issues - space-like, time-like, null intervals. Simultaneity and co-placement. Length contraction and time dilation.
- Relativistic description of matter - energy-momentum tensor $T_{\mu\nu}$. (Ambitious version - $T_{\mu\nu}$ from the Lagrangian formulation). Equations of motion.
- Application to Electromagnetism.

Part II: General Relativity – Geometrical Theory of Gravity – 9 lectures.

- Introduction to tensors, contravariant and covariant tensors.
- Parallel transport of the vectors. Connection. Covariant differentiation. Parallel transport over closed loop. Curvature.
- Distances in the curved space-time. Line element and the metric tensor. Relation between metric tensor and connection in Riemannian spaces. Examples of the curved spaces.
- Motion of the massive and massless particles in the curved space-time. Geodesic equation. Connection in the role of 'gravitational force'.
- Equivalence principle. Local elimination of the constant gravitational force. Identification of gravity and space-time geometry. Irreducible local effects of the gravity - tidal forces.
- Einstein equations. Ideas for their form. General properties of Einstein equations — space-time with matter necessarily curved, presence of purely gravitational degrees of freedom, inclusion of the equation of motion.
- Weak field regime, Newtonian potential, Gravitational lensing.

Part III: General Relativity – Fundamental Results – 7 lectures.

- Spherically-symmetrical gravitational field. Schwarzschild metrics. Black holes.
- Homogeneous and isotropic cosmological solutions. Expanding Universe.
- Gravitational waves. Modern perspectives to detect gravitational waves.

Grading system

Description	Letter Grade	Grade Point Value
Excellent	A+	4.0
	A	4.0
	A-	3.7
Good	B+	3.3
	B	3.0
	B-	2.7
Satisfactory	C+	2.3
	C	2.0
	C-	1.7
Poor	D+	1.3
Minimal Pass	D	1.0
Failure	F	0.0