outline

Topic	**Reading**
• I Special relativity (4 lectures)	
• 1 Historical origins, postulates and spacetime	§ 2.1 – .13 (14)
• The tension between Newton and Maxwell	
• Postulates and assumptions of special relativity	
• Simultaneity and spacetime	
• 2 Relativistic kinematics	§ 3.1 – .6, .10 (10)
• The Minkowski metric	
• Lorentz transformations	
• Kinematic effects	
• 3 Relativistic dynamics	§ 3.7; 4.1 – .5 (12)
• Accelerated motion	
• Scalar and vector forces	
• Energy and momentum	
• 4 Non-Inertial motion and the equivalence principle	§ 3.8 – .9; 9.1 – .4 (14)
• Uniformly accelerated observers	
• Machian theories and equivalence	
• What is gravity?	
• II A crash course on Riemannian geometry (3 lectures)	
• 1 Differentiable manifolds	§ 5.1 – .9; 6.1, .2 (17)
• Manifolds and smooth functions	
• Vector and tensor fields	
• Mappings of manifolds and the Lie derivative	
• 2 Riemannian geometry	§ 6.3 – .12; 7.7 (18)
• Affine connections and curvature	
• Metric geometry	
• Isometries	
• 3 Integration on manifolds	§ 7.1 – .4 (6) +
• Differential forms and integrals	
• Volume and the Hodge dual	
• The generalized Stokes theorem	
• III Foundations of general relativity (6 lectures)	
• 1 Minkowski spacetime as a particular gravitational field	§ 7.5 – .6; 8.1 – .8 (18)
• A geometric perspective on special relativity	
• Geodesics and mechanics	
• Symmetry and conservation laws	
• 2 Gravity as geometry	§ 9.5 – .7; 10.1 – .7 (13)
• Tidal forces and geodesic deviation	
• The Einstein field equation	

Topic	**Reading**
• Uniqueness of Einstein's theory	
• 3 Gravitational sources	§ 12.1 – .8 (11)
• Matter sources	
• Einstein–Maxwell theory	
• Energy conditions	
• 4 The nature of the field equations	§ 13.1 – .7 (11)
• Constraints and gauge	
• The Cauchy problem	
• The cosmological constant	
• 5 Motion in curved spacetime	§ 12.9, .10; 20.1, .2 (8) +
• The Newtonian limit	
• The post-Minkowski expansion	
• *Does the field equation predict source motion?*	
• 6 *Action principles for gravity	§ 11.1 – .8 (9)
• The Einstein–Hilbert action	
• The Palatini action	
• Coordinate invariance	
• IV Isolated gravitational sources (6 lectures)	
• 1 The Schwarzschild solution	§ 14.1 – .6 (10)
• Stationary and static metrics	
• Spherical symmetry	
• Solving the Einstein equation	
• 2 Signatures of relativistic gravity	§ 15.1 – .5 (13)
• Perihelion advance	
• Deflection of light	
• Gravitational red shift	
• 3 The Schwarzschild black hole	§ 16.1 – .8 (12)
• Singularities of the Schwarzschild solution	
• Eddington–Finkelstein coordinates	
• The event horizon	
• 4 Global structure of the Schwarzschild solution	§ 17.1 – .5 (9)
• The Kruskal extension	
• Conformal compactification	
• Penrose diagrams	
• 5 *Spherical stars	+
• Interior solutions in spherical symmetry	
• Hydrostatic equilibrium	
• The Chandrasekhar limit	
• 6 *Rotating black holes	§ 19.3 – .10 (12)
• The Kerr metric	
• Spacetime structure	

Topic	Reading
• Maximal rotation	
• 7 *General features of black holes	§ 18.1 – .5; 19.11 – .12 (13)
• What is a black hole?	
• Singularity and uniqueness theorems	
• Quantum effects	
• V Gravitational radiation (5 lectures)	
• 1 Plane gravitational waves	§ 20.3 – .5, .9 (12)
• Plane waves in linearized gravity	
• Exact plane-wave solutions	
• Detecting gravitational waves	
• 2 Weak gravitational waves from compact sources	+
• Radiation gauge in linearized gravity	
• Sources of gravitational radiation	
• The quadrupole formula	
• 3 Asymptotic description of gravitational radiation	§ 21.1 – .6 (10)
• Radiation coordinates	
• Characteristic formulation of general relativity	
• Bondi news	
• 4 *Local characterization of gravitational radiation	§ 6.13; 21.7 – .9 (5) +
• Algebraic classification of metrics	
• The peeling-off theorem	
• Null congruences and propagation	
• 5 *Radiation reaction in general relativity	+
• The Dirac approach to radiation reaction	
• Second-order perturbation theory	
• Source motion and integrability	
• VI Relativistic cosmology (4 lectures)	
• 1 Homogeneous and isotropic spacetimes	§ 22.1 – .8 (15)
• The cosmological principle	
• Homogeneity and isotropy	
• Spaces of constant curvature	
• 2 Basic cosmological phenomenology	§ 22.9 – .12 (8)
• The Friedmann equation	
• Observables in cosmology	
• Hubble's law	
• 3 Simple cosmological models	§ 23.1 – .10 (13)
• The role of the cosmological constant	
• Classification of Friedmann solutions	
• Dark matter and dark energy	
• 4 *Global structure of cosmological spacetimes	§ 23.12 – .16 (11) +
• Cosmological horizons	

Topic	Reading
• Conformal structure of cosmological solutions • *Asymptotically simple spacetimes* • 5 *Quantum cosmology • Symmetry reduction of the action • Canonical quantization • Relation to quantum gravity	+