Physics PhD Qualifying Exam
Paper 2 – Syllabus

Preface

- Paper 2 exam is the second phase of the Ph.D. Qualifying Exam of the Physics Department, which is fully in accordance with the Department's Rules and Regulations for Graduate Studies (valid until the change of the Department's Rules and Regulations for Graduate Studies is made).

- This document comprises area based topics for Paper 2 of the Ph.D. Qualifying Exam in Physics department. The present Paper 2 exam is specially designed for **Gülnihal Tokgöz**, who is currently PhD student in the department of Physics.

- The subjects covered in this Paper 2 are from General Undergraduate Physics (Optics and Modern Physics, and Classical Mechanics), PHYS603 Special Topics in General Relativity - I, and PHYS605 Selected Topics in General Relativity - III.

- The reference textbooks are indicated at the end of each course.

1. General Undergraduate Physics

a. Classical Mechanics

Topics covered

Lagrangian mechanics; Hamiltonian mechanics; the two-body central force problem; dynamics of a system of particles; motion in a non-inertial reference frame; rigid body motion; small oscillations.

Bibliography

Stephen T. Thornton and Jerry B. Marion (2012) *Classical Dynamics of Particles and Systems (5th Edition)* Thomson Learning, Brooks/Cole, California, USA

b. Optics and Modern Physics

Topics covered

Optics: ray model of light; reflection and refraction; mirrors; thin lenses, simple optical instruments, waves, interference, diffraction, polarization.

Modern Physics: special theory of relativity, particle properties of waves, wave properties of particles, Bohr model of atoms; introduction to quantum mechanics, nucleus and radioactivity.

Bibliography

Raymond A. Serway and John W. Jewett (2012) *Physics for Scientists and Engineers with Modern Physics (9th Edition)* Cengage Learning, Boston, USA

2. PHYS603 Special Topics in General Relativity - I

Topics covered

1. Newman-Penrose formalism
2. Types of black holes and proper tetrad transformation
3. Black hole perturbations: Klein-Gordon equation, Dirac equation, Maxwell equation, and Proca equation
4. Computation of Hawking radiation from the exact solution of a wave equation
5. Quasinormal modes and boxed quasinormal modes: Resonance and cloud problems of black holes
6. Quantization of area/entropy of a black hole
7. Greybody factors of black holes
8. Absorption and cross-section rate of black holes
9. Stability problems of black holes
10. Gravitational lensing

Bibliography

S. Chandrasekhar, *The Mathematical Theory of Black Holes* (Oxford University Press, New York, 1983).
V. Frolov and I. Novikov, *Black Hole Physics: Basic Concepts and New Developments, Fundamental Theories of Physics* (Kluwer Academic, London, 1998).
R. M. Wald, *General Relativity* (The University of Chicago Press, Chicago and London, 1984).
J. B. Griffiths and J. Podolský, *Exact Spacetimes in Einstein's General Relativity* (Cambridge University Press, Cambridge, 2009).
M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions* (Dover, New York, 1965).

3. PHYS605 Special Topics in General Relativity - III

Topics covered

1. Fundamentals of General Relativity: Tensors and operations with them
2. Curved spacetimes, vielbeins, and covariant differentiation
3. Kerr black hole: Integrals of motion, surface area, zero angular momentum, circular singularity, natural angular velocities
4. Killing vectors: How to compute them? and their physical features
5. The laws of black hole mechanics
6. Surface gravity computation via Killing vectors: Hawking temperature
7. Entropy and angular momentum of a black hole
8. Quantum tunneling from black holes: Hamilton-Jacobi, Parikh-Wilczek, and Damour-Ruffini-Sannan methods
9. Exact Solutions to the geodesics equations

Bibliography

R. M. Wald, General Relativity (The University of Chicago Press, Chicago and London, 1984).
V. Frolov and I. Novikov, *Black Hole Physics: Basic Concepts and New Developments, Fundamental Theories of Physics* (Kluwer Academic, London, 1998).
S. Chandrasekhar, *The Mathematical Theory of Black Holes* (Oxford University Press, New York, 1983).
J. B. Griffiths and J. Podolský, *Exact Spacetimes in Einstein's General Relativity* (Cambridge University Press, Cambridge, 2009).