Course Syllabus

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Phys 541 Electromagnetic Theory (3)
TEXT: One major course book.

M. Chaichian et al. “Electrodynamics – An Intensive Course”, Springer Verlag, 2016, ISBN 978-3-642-17380-6 ISBN 978-3-642-17381-3 (eBook) DOI 10.1007/978-3-642-17381-3 (free download using UTK-library Springer- link).

Standard course aim

Review of electrostatics, magnetostatics, and quasi-static problems; Maxwell’s field equations and their solutions in dielectric and conducting media; electrodynamics and relativity, retarded potentials and gauge transformations, radiation produced by accelerating charges. (DE) Prerequisite(s): 571.

Course overview

The course will be structured according to the table-of-contents of the main course book. The first lecture on January 24, 2022, 10:30-11:20 am (EST) will address aspects of the course syllabus, aim, goals and objectives including homework, midterm- and final exams weights.

There are eight homework exercise sheets, four in the first half and four in the second half of this course, plus a mid-term and a final exam.

The distribution of weights is of the order of 67% for eight homework assignments, 11% for midterm and 22% for final exams, plus an extra 2% for filling in the TN-Voice course survey. Homework exercise sheets and exams will have four questions each and four points per question.

Scaling for each question: 4 pts - outstanding, 3 pts - OK, 2 pts - about 50% OK, 1 pt - attempted but needs major work.

Supplementary reading as part of your study of classical electrodynamics should include

(i) W. Greiner “Classical Electrodynamics”, Springer Verlag, New York, NY, USA, ISBN 0-387-94799-X (nice reference for a slew of solved problems)

(ii) B. Thidé “Electromagnetic Field Theory”, Upsilon books, Uppsala, SE (some aspects of field theory and solved sets of problems)

(iii) J.D. Jackson “Classical Electrodynamics”, Wiley, NH, USA, 3rd Ed. ISBN 047130932X (historic, most problems are nicely solved and freely available through electronic files)

Overview of Lectures - planned schedule for contents of the various lectures 1 to 42, grouped into 14 sets of three lectures

#1: 01/24 - 01/28

Overview, main course book table of contents, aims goals objectives, exercise schedules, grading

Classic books for electromagnetic (elm) theory: Greiner, Jackson, Thide - exercises

Appendix A: Standard vector analysis, Christoffel symbols

#2: 01/31 - 02/04

Appendix E: Dirac delta distribution, Fourier expansion

Electrostatics fundamentals, up to p.17, separation of variables

Electrostatic field energy, up to p.62 Poisson equation in spherical coordinates

Homework #1. Due 02/04. 1 week for HW

#3: 02/07 - 02/11

Appendix B: Tensors, covariant, contravariant, metric, operators

Appendix D: curvilinear coordinates, Appendix F: Green function

Ch2: Fundamentals of "magnetostatics" up to p.91

Homework #2. Due 02/11.

#4: 02/14 -02/18

Ch2: Vector potential, determination of 3d vector potential for selected cases

Ch3: Maxwell's equation in vacuo and polarizable media, up to p.130

Ch3: Poynting theorem, Maxwell stress tensor, up to p.137

Homework #3. Due 02/18.

#5: 02/21 - 02/25

Ch3: Elm potentials, Lagrangian and Hamiltonian approaches, motion of charged particle in stationary magnetic field with axial symmetry

Ch4: Elm waves, up to p.183

Ch4: Propagation of elm waves, selected topics, up to p.206

Homework #4. Due 02/25.

#6: 02/28 - 03/04

Ch4: Dispersion of elm waves up to p.219

Ch4: Kramers-Kronig relations and selected topics up to p.239

Ch4: Elm radiation, retarded and advanced elm potentials up to p.249

#7: 03/07 - 03/11

Ch4: Lienard-Wiechert potentials; near&intermediate&far zones of charge distributions

Ch4: Electric dipole radiation and antenna considerations

Ch4: Discussion of selected problems and solutions pp.282-296, contd.

Midterm. Due 03/11. 1 week for Midterm.

#8: 03/21 - 03/25

Ch4: Continued discussion of problems and solutions for vector potentials.

Ch5: Elements of magnetofluid dynamics

Ch5: Motion of electrons in crossed electric and magnetic fields, up to p.334

#9: 03/28 - 04/01

Appendix C: Minkowski space

Ch6: Special theory of relativity aspects, Lorentz boosts, up to p.353

Ch6: Lorentz transformation of elm fields, Faraday tensor, selected topics

Ch7: Minkowski space, favoring the hyperbolic representation up to p.391

Homework #5. Due 04/01.

#10: 04/04 - 04/18

Ch7: Lorentz group, up to p.399

Ch7: Relativistic dynamics, up to p.436, contd.

Ch7/Ch8: Continued relativistic dynamics, discussion of selected problems and solutions including solved problems from Ch8.

Homework #6. Due 04/08.

#11: 04/11 - 04/18

Ch8: Relativistic formulation of electromagnetic theory, up to p.443, and covariant form of Maxwell's equations, up to p.463. Continued discussion of selected problems.

Ch8: Four-potentials, diff. eqs., solutions; Noether's theorem & symmetries, up to p.472, Energy-momentum tensor, angular momentum tensor, up to p.511.

Homework #7. Due 04/18.

Ch8: Continued Noether theorem and selected problems Ch8, Proca equation, class notes [quaternions, Proca equation, quantization of elm field.]

#12: 04/20 - 04/25

Ch9: General theory of relativity, overview and 3d-review of geodesics

Ch9: Geodesics, up to p.525

Homework #8. Due 04/25.

Ch9: Riemann and Ricci tensors, comparison of elm and gravitational fields, up to p.541

#13: 04/27 - 05/02

Ch9: Einstein's equations,

Ch9: Schwarzschild-metric solution

Ch9: Discussion of various metrics, perihelion precession

#14: 05/04 - 05/09

Ch9: Tests of general relativity: Gravitational lensing, up to p.566

Ch9: Gravitational red shift.

Ch9: Discussion of further tests of GR, LIGO,

Last Meeting: Review/Discussion of elm theory course.

Finals. Due 05/13. 1 week for Finals.

Course Summary:

Date	Details	Due
Fri Feb 4, 2022	HW1 (https://utk.instructure.com/courses/144666/assignments/1107440)	due by 11:59pm
Fri Feb 11, 2022	HW2 (https://utk.instructure.com/courses/144666/assignments/1107441)	due by 11:59pm
Fri Feb 18, 2022	HW3 (https://utk.instructure.com/courses/144666/assignments/1107442)	due by 11:59pm

Date	Details	Due
Fri Feb 25, 2022	HW4 (https://utk.instructure.com/courses/144666/assignments/1107443)	due by 11:59pm
Fri Mar 11, 2022	Midterm (https://utk.instructure.com/courses/144666/assignments/1107444)	due by 11:59pm
Fri Apr 1, 2022	HW5 (https://utk.instructure.com/courses/144666/assignments/1107448)	due by 11:59pm
Fri Apr 8, 2022	HW6 (https://utk.instructure.com/courses/144666/assignments/1107449)	due by 11:59pm
Mon Apr 18, 2022	HW7 (https://utk.instructure.com/courses/144666/assignments/1107450)	due by 11:59pm
Mon Apr 25, 2022	HW8 (https://utk.instructure.com/courses/144666/assignments/1107451)	due by 11:59pm
Fri May 6, 2022	Completed Survey (https://utk.instructure.com/courses/144666/assignments/1107447)	due by 11:59pm
Fri May 13, 2022	Final Exam (https://utk.instructure.com/courses/144666/assignments/1107446)	due by 11:59pm