



## Lahore University of Management Sciences

### PHY 404 / PHY 504 – Relativistic Electrodynamics

Fall 2023

To understand how to navigate course outlines, consult: How to Use a Course Outline (<http://surl.li/gpvuw> )

Instructor	Moez Hassan
Room No.	9-111A
Office Hours	TBA
Email	syed_hassan@lums.edu.pk
Telephone	
Secretary/TA	
TA Office Hours	
Course URL (if any)	LMS
Support Services	LUMS offers a range of academic and other services to support students. These are mentioned below, and you are encouraged to use these in addition to in-class assistance from course staff. For a complete list of campus support services available for you click here ( <a href="https://advising.lums.edu.pk/#supportservices">https://advising.lums.edu.pk/#supportservices</a> )

#### Course Teaching Methodology

- Teaching Methodology: Lectures will be in-person on-campus. All Covid related SOPs are to be strictly followed in the classroom. Unless medically exempted, all students sitting in the class must be fully vaccinated (i.e., they must have received the final dose of their vaccine at least 14 days prior to the start of classes).

#### Course Basics

Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Durati on	1 hour 15 minutes
Recitation/Lab (per week)	Nbr of Lec(s) Per Week		Durati on	
Tutorial (per week)	Nbr of Lec(s) Per Week		Durati on	

#### Course Distribution

Core	Physics Core
Elective	
Open for Student Category	All
Close for Student Category	None



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### COURSE DESCRIPTION

This course has two parts. The first part deals with the special theory of relativity (*beyond* the Freshman level). The second part deals with the fully relativistic formulation of electrodynamics with applications. We will begin with a detailed introduction of special theory, and will see how we can build up the magnetostatics and electromagnetics in free space just from the Coulomb's law and the relativistic transformation of charges and force. We will also study the motion of charged particles in electromagnetic fields and the fields radiated by relativistically moving charged particles. Lagrangian formulation for charged particles in external electromagnetic fields will also be introduced.

### COURSE PREREQUISITE(S)

- For Undergrad: PHY 305 Electromagnetic Fields and Waves
- For Grad: PHY 501 Electrodynamics (with a grade of B- or above) OR Instructor's Permission

### Learning Outcomes (CLO)

CLO-1: Students will be able to understand and apply the special theory of relativity in mechanics and electrodynamics problems.

CLO-2: Students will be able to use the Lorentz transformations to convert Coulomb's law to magnetostatics equations and appreciate the fully relativistic nature of Maxwell's equations.

CLO-3: Students will be able to describe the radiations emitted by relativistic charged particles.

CLO-4: Students will be able to express electromagnetism in the language of tensors, perform calculations with it and write down Lagrangians for electromagnetic systems.

### Grading Breakup and Policy

Component	Weightage	Description
Assignments	20%	<ul style="list-style-type: none"> <li>• Approximately 1 each week.</li> <li>• N/2</li> <li>• Late Submissions: 10% penalty per day, upto a maximum of 30% (3 days late).</li> <li>• HW grading scheme (0, 1 or 2 points for each problem):               <ul style="list-style-type: none"> <li>○ 2 points: Problem solved completely and correctly with margin for a minor error.</li> <li>○ 1 point: Problem incomplete, multiple minor errors, or a major error.</li> <li>○ 0 points: Problem not attempted, multiple major errors, or an incoherent solution.</li> </ul> </li> </ul>
Quizzes	5%	



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		<ul style="list-style-type: none"> <li>Quiz-1 ('Prep Quiz') will be of 10% weightage and will cover all the necessary pre-requisite materials for this course including Maxwell's equations, vector calculus, and special relativity.</li> <li>Quiz-2 to Quiz-6 will be of 6% weightage each (30% total), and there will be an N-1 on these (i.e., best 4 out of 5 will count from Quiz-2 to Quiz-6).</li> <li>Dates: <ul style="list-style-type: none"> <li>Quiz-1: 22<sup>nd</sup> September</li> <li>Quiz-2: 6<sup>th</sup> October</li> <li>Quiz-3: 20<sup>th</sup> October</li> <li>Quiz-4: 3<sup>rd</sup> November</li> <li>Quiz-5: 17<sup>th</sup> November</li> <li>Quiz-6: 1<sup>st</sup> December</li> </ul> </li> <li>All of these will be held live in-class.</li> </ul>
Mid	30%	
Final Exam	45%	<ul style="list-style-type: none"> <li>Comprehensive final exam</li> </ul>

- The instructor reserves the right to vary these grade assignments or add new instruments by upto 10%.
- In the event that the course has to be shifted online, this grading breakup (and the details) may be substantially revised.
- University policy for cheating/unfair means will be applicable on all grading instruments. You must submit your own work. If any evidence of plagiarism is found, these cases will be forwarded straight to the School DC.**

### **COURSE POLICIES (READ CAREFULLY):**

- All Covid related SOPs are to be strictly followed in the classroom. Unless medically exempted, all students sitting in the class must be fully vaccinated (i.e., they must have received the final dose of their vaccine at least 14 days prior to the start of classes).
- All emails** sent to the instructor or TAs must have a **subject line** of the following format (examples):  
"PHY 404--subject line" OR "PHY 504--subject line"
- All emails** must be signed with name and **roll-number**.
- If you email me asking me a question that is already answered in the outline, I will not answer your email.
- All announcements will be posted on LMS (with an email notification). **It is your responsibility** to regularly check the LMS site for this course.
- Please come on time. No talking/disturbance during class. No cell-phones, laptops etc. during class.
- Missed quiz/HW:** A zero will be awarded for a missed quiz/HW. For an approved petition from the OSA, student's own average in the remaining quizzes/HWs will be given for the missed quiz/HW.
- Graduate students** (those enrolled in PHY 504) **will be** assigned extra work.



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Examination Detail	
Midterm Exam	Yes/No: No Combine Separate: Duration: Preferred Date: Exam Specifications:
Final Exam	Yes/No: Yes Combine Separate: Duration: 3 hours Exam Specifications: Closed book, closed notes.

### Tentative list of topics:

Lectures	Topic	Recommended Readings	CLO
<b>Special Relativity</b>			
1-3	Geometric formulation of special relativity, the structure of spacetime, spacetime interval		1
4-7	Vectors, one-forms and tensors, the metric		1
8-9	The Lorentz group		1
<b>Relativistic Electrodynamics</b>			
10-14	EM waves, magnetism from relativity, potentials		2
15-18	Green's functions and solving the wave equations		2
19-23	Radiation from moving charges		3
24-26	EM field tensor, Lagrangian formulation		4
27-28	[Time Permitting] Selected Advanced Topics		4

Textbook(s)/Supplementary Readings



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1. A first course in General Relativity, Schutz
2. Griffiths, Introduction to Electrodynamics
3. A. Zangwill, "Modern Electrodynamics"
4. J.D. Jackson, Classical Electrodynamics

### Reference:

Resnick, Introduction to Special Relativity

Melvin Schwartz, Principles of Electrodynamics

R. S. Elliot, "Electromagnetics: History, theory, and applications"

### Campus supports & Key university policies

#### Campus Supports

Students are strongly encouraged to meet course instructors and TA's during office hours for assistance in course-content, understand the course's expectations from enrolled students, etc. Beyond the course, students are also encouraged to use a variety of other resources. (Instructors are also encouraged to refer students to these resources when needed.) These resources include Counseling and Psychological Services/CAPS (for mental health), LUMS Medical Center/LMC (for physical health), Office of Accessibility & Inclusion/ OAI (for long-term disabilities), advising staff dedicated to supporting and guiding students in each school, online resources (<https://advising.lums.edu.pk/advising-resources>), etc. To view all support services, their specific role as well as contact information click here (<https://advising.lums.edu.pk/#supportservices>).

#### Academic Honesty/Plagiarism

LUMS has zero tolerance for academic dishonesty. Students are responsible for upholding academic integrity. If unsure, refer to the student handbook and consult with instructors/teaching assistants. To check for plagiarism before essay submission, use [similarity@lums.edu.pk](mailto:similarity@lums.edu.pk). Consult the following resources: 1) Academic and Intellectual Integrity (<http://surl.li/gpvwb>), and 2) Understanding and Avoiding Plagiarism (<http://surl.li/gpvwo>).

#### LUMS Academic Accommodations/ Petitions policy

Long-term medical conditions are accommodated through the Office of Accessibility & Inclusion (OAI). Short-term emergencies that impact studies are either handled by the course instructor or Student Support Services (SSS). For more information, please see Missed Instrument or 'Petition' FAQs for students and faculty (<https://rb.gv/8sj1h>)

#### **LUMS Sexual Harassment Policy**

LUMS and this class are a harassment-free zone. No behavior that makes someone uncomfortable or negatively impacts the class or individual's potential will be tolerated.

To report sexual harassment experienced or observed in class, please contact me. For further support or to file a complaint, contact OAI at [oai@lums.edu.pk](mailto:oai@lums.edu.pk) or [harassment@lums.edu.pk](mailto:harassment@lums.edu.pk). You may choose to file an informal or formal complaint to put an end to the offending behavior. You can also call their Anti-Harassment helpline at 042-35608877 for advice or concerns. *For more information: Harassment, Bullying & Other Interpersonal Misconduct: Presentation* (<http://surl.li/qpvwt>)