**Name of Institute: Indus Institute of Sciences, Humanities and Liberal Studies (IISHLS)**
**Name of Faculty: Dr. Tanushree Basak**

## Course code: MPH0302
## Course name: Electrodynamics and Plasma Physics

Pre-requisites: B.Sc Physics (Calculus, EMT theory, Electrostatics)
Credit points: 04
Offered Semester: III

**Course Coordinator (weeks 01 - 17)**
Full name: Dr. Tanushree Basak
Department with sitting location: Physics Department, Physics lab
Telephone: 3314 (sitting location), 9374979897 (Mobile)
Email: tanushreebasak.gd@indusuni.ac.in
Consultation times: 1:30 pm to 4:45 pm (Friday)

**Course Lecturer (weeks 01 - 17)**
Full name: Dr. Tanushree Basak
Department with sitting location: Physics Department, Physics lab
Telephone: 3314 (sitting location), 9374979897 (Mobile)
Email: tanushreebasak.gd@indusuni.ac.in
Consultation times: 1:30 pm to 4:45 pm (Friday)

Students will be contacted throughout the Session via Mail with important information relating to this Course.

## Course Objectives

By participating in and understanding all facets of this Course a student will be able:

- Introducing the mathematical tools used in electrodynamics.
- Providing easy headway into the covariant formulation of Maxwell's equations.
- Rendering insights into fields generated by oscillating sources, and their applications.
- To impart the knowledge about the fundamental and basics of Plasma Physics.
- To learn about the charged particle motion in electric and magnetic field.
- To provide the knowledge about the ionization process and diffusion.

## Course Outcomes (CO)

1) Ability to use basic mathematical tools to solve problems in electrodynamics.
2) Gaining proficiency in solving real life problems in electrostatics and magnetostatics.
3) Understanding the radiation phenomena by moving charges.
4) Will have an idea about the basis of Plasma (Fourth State of Matter).
5) Able to visualize the motion of charged particles in electric and magnetic field.
6) Gaining knowledge about the ionization and diffusion of Plasma.

## Course Outline

### Unit: 1

Solution of Maxwell's equations with nonzero charge and current density, scalar and vector potentials, Gauge transformations, Lorentz and Coulomb gauges, solution of inhomogeneous wave equation, retarded and advance Green function , retarded potentials.
Non-relativistic multipole radiations: Electric dipole and quadruple radiations.

### Unit: 2

Radiations by moving charges: Lienard-Weinchert potentials and field for a point charge, total power radiated by an accelerated charge (Larmor's Formula and its relativistic generalization). Angular distribution and frequency spectrum of the radiation power. Covariant formulation of electromagnetic theory: Mathematical
properties of space time of special relativity, Matrix representation of Lorentz transformation, Invariance of electric charge, covariance of electrodynamics, Transformation of electromagnetic field (Lorentz force)

### Unit: 3

Magnetohydrodynamics(MHD) and Plasma Physics: Introduction and definitions, MHD equations, Magnetic diffusion, viscosity and pressure, Magnetohydrodynamic flow between boundaries with crossed electric and magnetic fields, Magnetohydrodynamical waves, pinch effects. Instability in a pinched plasma column

### Unit :4

Particle drift in non-uniform static magnetic fields, Magnetic mirrors, adiabatic invariance of flux through orbit of a particle, Two stream instability, Kinetic treatment of plasma oscillations and Landau damping physical explanation, Potentials and problems of controlled thermonuclear fusion, Ignition

temperature and Lawson criteria, Magnetic confinement, Simple discussion of Tokomak and Z-pinch

## Method of delivery

(Face to face lectures, Power Point Presentation, Self assessment, Active Learning Techniques)

## Study time

(4 hours per week for lectures)

## Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

| General Graduate Qualities | Specific Department of _____Graduate Capabilities |
|---|---|
| **Informed**<br>Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas. | **1 Professional knowledge, grounding & awareness**<br><br>**Concept of Quantum physics**<br>**Also application of the quantum physics principle in practical problems** |
| **Independent learners**<br>Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others. | **2 Information literacy, gathering & processing**<br><br>Critical and logical thinking is developed through numerical practice.<br>Used various sources of the material and technology to perform the experimental part. |
| **Problem solvers**<br>Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards. | **4 Problem solving skills**<br>**By practicing numerical, logical and critical thinking will be developed.** |
| **Effective communicators**<br>Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication. | **5 Written communication**<br>**Conducting frequent unit test will develop their written communication skill** |
| | **6 Oral communication**<br>**Arranging presentation on different physics topics throughout the semester** |
| | **7 Teamwork**<br>**Group discussion in class and lab is arranged** |
| **Responsible**<br>Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities. | **10 Sustainability, societal & environmental impact** |

## Lecture/tutorial times

***Example:***

| | | | |
|---|---|---|---|
| Lecture | Monday | 10:30–11.30 am | Room Class-CL-08, 5th floor |
| | Wednesday | 10:30–11.30 am | Room Class-CL-08, 5th floor |
| | Thursday | 10:30–11.30 am | Room Class-CL-08, 5th floor |
| | Friday | 10:30–11.30 am | Room Class-CL-08, 5th floor |

## Details of referencing system to be used in written work

Unit test will be conducted in the classes and test papers will be kept with course coordinator for the future reference.

## Text books

1. Classical Electrodynamics : Jackson J.D. 2 nd Edition John Wiley & Sons New York, 1963.
2. Introduction to Plasma Physics and Controlled fusion :F. F. Chen. 2nd Edition Plenum Press, New York London 1984

## Additional Materials

- Classical Electricity and Magnetism: Panofsky W. K. H. and M. Phillips, 2nd Edition, Reading Mass.: Addison-Wesley (AW) 1962.
- Feynman Lectures, Vol.-II. AW, MIT reading 1965, Narosa Pub. 1995
- Introduction to Electrodynamics: D. J. Griffiths. 3 rd Ed. PHI, New Delhi 2001
- Classical Electrodynamics: S. P. Puri, Tata McGraw-Hill Publ. Company Ltd.New Delhi 1990

**Web resources:**

**https://ocw.mit.edu/courses/nuclear-engineering/22-611j-introduction-to-plasma-physics-i-fall-2003/lecture-notes/**

**https://ocw.mit.edu/courses/physics/8-07-electromagnetism-ii-fall-2012/**

**https://sites.evergreen.edu/psam1617/introduction-to-electrodynamics-video-series/**

**MOOCs:**

https://nptel.ac.in/courses/115/101/115101004/

https://nptel.ac.in/courses/115/102/115102020/

## ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

| | | |
|---|---|---|
| **Continuous Internal Evaluation (Theory)** | | |
| **Mid Sem Exam** | 40% , Unit-1/2, Objective (1,2,3) | |
| **Assignments** | **10% , Objective (1,2,3)** | |
| **Project/Presentation** | 5% , Objective (1,2,3) | |
| Attendance | 5% | |
| **Total** | **60% (CIE theory)** | |
| **Final exam** (*closed book*) | 40% | Objectives (1-3) |

## SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 50% in CIE or end semester will be considered for supplementary assessment in the respective components (i.e CIE or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 50% marks to clear the concerned components.

## Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -50% of the maximum mark per calendar day

## Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

## Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

## University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

**Plagiarism** - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

***Do not copy the work of other students.***
***Do not share your work with other students (except where required for a group activity or assessment.***

Course schedule(subject to change)

| | Week # | Topic & contents | CO Addressed | Teaching Learning Activity (TLA) |
|---|---|---|---|---|
| | Weeks 1 | Solution of Maxwell's equations with nonzero charge and current density, scalar and vector potentials | 1,2 | PPt, chalk and board |
| | Weeks 2 | Gauge transformations, Lorentz and Coulomb gauges, solution of inhomogeneous wave equation | 1,2 | Chalk and Board |
| | Week 3 | Retarded and advance Green function , retarded potentials. | 1-3 | Chalk and Board |
| | Week 4 | Non-relativistic multipole radiations: Electric dipole and quadruple radiations. | 1-3 | Chalk and Board |
| | Week 5 | Radiations by moving charges: Lienard-Weinchert potentials and field for a point charge | 1-3 | PPT and chalk-board |
| | | | | |
| | Week 6 | total power radiated by an accelerated charge (Larmor's Formula and its relativistic generalization) | | Chalk and board |
| | Week 7 | Angular distribution and frequency spectrum of the radiation power. Covariant formulation of electromagnetic theory: Mathematical properties of space time of | 1-3 | Ppt and chalk and board, Test |

| | | | | |
|---|---|---|---|---|
| | | special relativity | | |
| | Week 8 | Matrix representation of Lorentz transformation, Invariance of electric charge, covariance of electrodynamics, Transformation of electromagnetic field (Lorentz force) | 1-3 | Ppt and chalk-board |
| | Week 9 | Magnetohydrodynamics(MHD) and Plasma Physics: Introduction and definitions, MHD equations, Magnetic diffusion | 4-5 | PPt, chalk and board |
| | Week 10 | iscosity and pressure, Magnetohydrodynamic flow between boundaries with crossed electric and magnetic fields | 4-5 | PPt, chalk and board |
| | Week 11 | Magnetohydrodynamical waves, pinch effects. Instability in a pinched plasma column | 4-5 | Chalk and board |
| | Week 12 | Particle drift in non-uniform static magnetic fields, Magnetic mirrors, adiabatic invariance of flux through orbit of a particle | 4-5 | Chalk and board, Test |
| | Week 13 | Two stream instability, Kinetic treatment of plasma oscillations and Landau damping physical explanation | 4-6 | PPTs and Chalk and board |
| | Week 14 | Potentials and problems of controlled thermonuclear fusion, Ignition temperature and Lawson criteria | 4-6 | PPTs and Chalk and Board |
| | Week 15 | Magnetic confinement, Simple discussion of Tokomak and Z-pinch | 4-6 | Chalk and Board |
| | Week 16 | Revision and Discussion | 1-6 | PPTs |
| | Week 17 | Revision and Discussion | 1-6 | Chalk and Board |

PROGRAM MAP for Bachelor of Engineering

**(Indus Institute of Sciences, Humanities and Liberal Studies)**

# Subject Mind Mapping