Universidad Carlos III de Madrid

COURSE TITLE: CLASSICAL ELECTRODYNAMICS		
EUROPEAN MASTER OF SCIENCE IN NUCLEAR FUSION AND ENGINEERING PHYSICS	YEAR: 1st	SEMESTER: 1st

COURSE SCHEDULE

WEEK	SESSION	DESCRIPTION OF THE CONTENTS	GROUP (Tick X)		Indicate if a space different from the classroom is required (laboratory, computer classroom, etc)	Indicate YES/NO if It is a session with two teachers (*)	STUDENT'S WEEKLY SCHEDULE		
			Lecture Class	Practical Class			DESCRIPTION	CLASS HOURS	HOMEWORK HOURS Máximum 7 H
1	1	**1. Electrostatics** - Electric field * Electric charge * Coulomb's law * Electric field * Continuous charge distributions - Helmholtz's theorem - Divergence of the electric field * Divergence of the electric field. Gauss' law * Gauss' law applications - Curl of the electric field * Curl of the electric field. Conservative property * Electric potential * The work done to move a charge * Electrostatic energy	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
1	2	(*) Discussion of selected exercises		X			(**) Solution of proposed exercises	1,5	

2	3	**1 (cont.)** - Conductors * Basic properties * Systems of conductors. Capacitors - Energy in electrostatics * The energy of a point charge distribution * The energy of a continuous charge distribution. Systems of conductors * Energy as a function of the electric field * Forces in a system of charges	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
2	4	(*) Discussion of selected exercises		X			(**) Solution of proposed exercises	1,5	
3	5	**1 (cont.)** - Special methods in electrostatics * Poisson and Laplace's equations * Properties of the Laplace's equation. Linearity and uniqueness theorem * The method of images * Separation of variables **2. Electric fields in matter** - Multipole expansion. The electric dipole	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
3	6	- (*) Discussion of selected exercises - Discussion of applications (plasma physics and nuclear fusion)		X			- (**) Solution of proposed exercises - Reading of applications, bibliographic research	1,5	
4	7	**2 (cont.)** - Polarization - The field of a polarized object. Bound charges - Gauss' law in the presence of dielectrics. The electric displacement - Linear dielectrics. Susceptibility, permittivity, dielectric constant - Boundary conditions - Energy in dielectric systems. Forces	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
4	8	- (*) Discussion of selected exercises		X			- (**) Solution of proposed exercises	1,5	

		- Discussion of applications (plasma physics and nuclear fusion)					- Reading of applications, bibliographic research		
5	9	**3 Magnetostatics** - Electric current * Current distributions. Current density * Continuity equation * Ohm's law. Conductivity and resistivity * Joule's law - Magnetic forces * Magnetic field B * Magnetic force on a moving charge. Cyclotron motion. Lorentz's force * Magnetic force on a current carrying wire. Magnetic moment of a loop of current * Magnetic force on volume and surface current distributions. Current element - The magnetic field of a steady current * Force between currents (Ampère's law) * The Biot-Savart law. Examples * Magnetic field due to volume and surface current distributions	X				- Reading of proposed topics - Work on the subject, including bibliographic research - (**) Solution of proposed exercises	1,5	7
5	10	**- Written test exam**		X			- Written test exam	1,5	
6	11	**3. (cont.)** - The divergence of B. Magnetic flux - The curl of B * The curl of B. Ampère's law * Applications of Ampère's law - Magnetic vector potential **4. Magnetic fields in matter** - Multipole expansion of the vector potential. The magnetic dipole	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
6	12	- (*) Discussion of selected exercises - Discussion of applications (plasma physics and nuclear fusion)		X			- (**) Solution of proposed exercises - Reading of applications, bibliographic research	1,5	
7	13	**4 (cont.)** - Diamagnetism, paramagnetism,	X				- Reading of proposed topics - Work on the subject, including	1,5	7

		ferromagnetism - Magnetization - The magnetic field of a magnetized object. Bound currents - Ampère's law in magnetized materials. The magnetic field H - Linear and nonlinear media: * Magnetic susceptibility and permeability * Ferromagnetism. Hysteresis - Boundary conditions - Magnetic circuits - Magnetic scalar potential					bibliographic research		
7	14	- (*) Discussion of selected exercises - Discussion of applications (plasma physics and nuclear fusion)		X			- (**) Solution of proposed exercises - Reading of applications, bibliographic research	1,5	
8	15	**5. Electromagnetic induction** - Electromotive force - Faraday's law of induction. Lenz's law - Moving circuits. Motional electromotive force - Stationary media. Induced electric field - Mutual inductance and self-inductance - Magnetic energy * Magnetic energy for a system of current-carrying circuits * Magnetic energy for steady current distributions * Energy as a function of the magnetic field * Losses due to hysteresis * Magnetic forces	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1.5	7
8	16	**- Written test exam**		X			- Written test exam	1.5	
9	17	**6 Electromagnetic properties of superconductors** - Introduction. Superconductivity. Critical temperature and critical magnetic field. Meissner effect. Type I and type II superconductors - Two descriptions for the magnetic state of superconductors:	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7

		* Perfect diamagnetic material * Material with free surface current - London's equations. London penetration depth							
9	18	- (*) Discussion of selected exercises - Discussion of applications (plasma physics and nuclear fusion)		X			- (**) Solution of proposed exercises - Reading of applications, bibliographic research	1,5	
10	19	**7. Maxwell's equations** - Generalized Ampères's law. Displacement current - Maxwell's equations - Maxwell's equations in matter - Boundary conditions - Conservation laws * Charge conservation. Continuity equation * Energy conservation. Poynting's theorem * Momentum conservation. Maxwell's stress tensor * Angular momentum	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
10	20	- (*) Discussion of selected exercises - Discussion of applications (plasma physics and nuclear fusion)		X			- (**) Solution of proposed exercises - Reading of applications, bibliographic research	1,5	
11	21	**8. Electromagnetic waves** - Electromagnetic waves in vacuum * The wave equation for E and B * Monochromatic plane waves * Energy and momentum in plane electromagnetic waves - Electromagnetic waves in matter * Propagation in linear media * Reflection and transmission at normal incidence * Reflection and transmission at oblique incidence	X				- Reading of proposed topics - Work on the subject, including bibliographic research - (**) Solution of proposed exercises	1,5	7
11	22	**- Written test exam**		X			- Written test exam	1,5	

12	23	**8. (cont.)** - Absorption and dispertion * Electromagnetic waves in conductors * Reflection at a conducting surface * The frequency dependence of permittivity - Guided waves * Wave guides. Transverse electric (TE) and magnetic (TM) modes. TE waves in a rectangular wave guide * Coaxial transmission line * Resonant cavities	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
12	24	- (*) Discussion of selected exercises - Discussion of applications (plasma physics and nuclear fusion)		X			- (**) Solution of proposed exercises - Reading of applications, bibliographic research	1,5	
13	25	**9. Potentials and fields** - Scalar and vector potentials - Lorentz gauge and Coulomb gauge - Wave equations for the potentials - Retarded potentials - Point charges * Liénard-Wiechert potentials * The fields of a moving point charge	X				- Reading of proposed topics - Work on the subject, including bibliographic research	1,5	7
13	26	- (*) Discussion of selected exercises		X			- (**) Solution of proposed exercises	1,5	
14	27	**10. Radiation** - What is radiation ? - Electric dipole radiation - Magnetic dipole radiation - Radiation from an arbitrary source - Power radiated by a point charge	X				- Reading of proposed topics - Work on the subject, including bibliographic research - (**) Solution of proposed exercises	1,5	7
14	28	**- Written test exam**		X			- Written test exam	1,5	
SUBTOTAL								**42 + 98 = 150**	
15		Support classes, delivery of proposed homework assignments, etc						5	5
TOTAL								**150**	

(*) Discussion of selected exercises from the course collection that correspond to the previous lecture
(**) Problem solving for selected exercises from the course collection
(***) Dates for topics of application to plasma physics and nuclear fusion sessions are tentative. They will be fixed in the beginning of the semester