Universidad Carlos III de Madrid

COURSE (6 CREDITS): ELECTROMAGNETICS (EM)		
DEGREE: GRADO EN INGENIERÍA EN TECNOLOGÍAS INDUSTRIALES	**YEAR:**	**SEMESTER:**

WEEKLY COURSE PROGRAMMING

WEEK	SESSION	DESCRIPTION	GROUP				WEEKLY PROGRAMMING FOR THE STUDENT		
			BIG	SMALL	Space necessary other than classroom	YES/NO 2 lecturers session (*)	DESCRIPTION	PRESENTIAL HOURS	HOMEWORK HOURS MAXIMUM 7 H
1	1	1. **Introduction to Electromagnetics. Review of prior concepts.** Introduction to the subject The Electromagnetism: a fundamental science for current technology. The Linear Fields and the Vector Differential Operators Sources of scalar Fields. Divergence Theorem. Sources of Vector fields (vortex). The curl. Stokes´ theorem	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	4
1	2			X	NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
2	3	**2. Maxwell's equations of EM field in vacuum.** The electromagnetic interaction. Properties. Irrotational and solenoidal fields The Helmholtz´s Theorem. Scalar and Vector Sources of Electromagnetic Field Axiomatic presentation of Maxwell's equations in vacuum.	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
2	4			X	NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
3	5	**ELECTRIC FIELD** **3. The Electrostatic Field in Vacuum** Scalar and Vector Sources of Electrostatic Field. Charge distributions.	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	

		Electric Potential Integral Equations. Gauss' theorem. Circulation in the electric field Poisson and Laplace equations Analytical Methods for problem solving in Electrostatics.							
3	6			X	NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
4	7	**4. The electric field in presence of materials** **4.0 Introduction to Electrical Properties of Matter. Fundamentals of Electrical Conduction** Introduction to Band Theory: Dielectrics, Conductors and Semiconductors. Fundamentals of Electrical Conduction. Types of conduction. Conduction in solids. Characteristic magnitudes: Current density. Conductivity, mobility, drag velocity. Generalized Ohm's Law Dissipated Power in conductors. Generalized Joule effect Conduction in other media. **4.1 Electric Field and Conductors in electrostatic equilibrium.** Properties of conductors in electrostatic equilibrium Systems of Conductors. Capacitors Conductors in electrostatic equilibrium: Problems solving. Electrostatic Images.	X		NO	NON	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
4	8				NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
5	9	**4.2. Electric Field and Dielectrics** Dipoles and multipoles Polarization of Matter. Electric polarization vector **P** Linear Dielectrics. Sources of P. Bound charge. Electric susceptibility. Breakdown field strength. Electric Displacement Vector. **D** Basic equations for D: **divD and rotD** Constitutive relations in the electric field. Electric Permittivity Boundary Conditions between dielectric media Nonlinear dielectrics. Ferroelectricity. Fundamentals and Applications	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
5	10						- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
6	11	**5 Energy and Force in the Electric Field** Electric energy of charge distributions: point charges, continuous distributions, conductors	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	

		Energy density in electric field. Forces and torques on conductors and dielectrics. Electrostatic pressure on conductors Joule effect							
6	12				NO	NO	**- Test.** Continuous evaluation of Electrostatic Work.	1,5	
7	13	**MAGNETIC FIELD** **6 Magnetostatics in vacuum and non-magnetic media** Sources of Magnetic Field. Non-existence of monopoles. Sources of Magnetic Field (rot B). Ampere's differential law The Magnetic Vector Potential A. Coulomb gauge. Properties Derivation of Biot-Savart's law. Circuital law Magnetic forces and torques	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
7	14				NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
8	15	**7. The Magnetic Field in Magnetic Media** Magnetization of Matter Vector **M**. Susceptibility Types: Diamagnetism, Paramagnetism, Ferromagnetism, ... Sources of **M**: Bound current. Magnetic poles Vector **H**. Constitutive relations in the magnetic field. Magnetic permeability. Sources of **H**, free current and magnetic poles Boundary conditions for magnetic vectors	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
8	16				NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
9	17	The Magnetic Circuit Introduction to the ferromagnetism. Properties. Curie temperature. Spontaneous magnetization Ferromagnetic domains. The hysteresis cycle. Dissipated power. Magnetic Materials: types and applications.	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
9	18				NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
10	19	**Time dependent EM fields** **8. Electromagnetic Induction** Discussion on Faraday`s flux rule and its exceptions Electric field vector sources. Maxwell equation of EM induction EM induction in moving systems Electric field and induced current. Total field Introduction to Superconductivity. Expressions of energy in terms of magnetic flux and magnetic potential.	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	

		Energy density in magnetic field							
11	20				NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
11	21	**9. The Ampere-Maxwell law and Maxwell's Equations** Vector sources of magnetic field. Displacement current Maxwell's equations of electromagnetic field in matter. Integral Equations Discussion on electromagnetism fundamental equations. Constitutive equations, Continuity Eq. Lorentz´s force, energy density in the EM field, Joule effect. Boundary conditions, Electromagnetic potential.	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
12	22				NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
12	23	**10. Electromagnetic Waves** The Wave Equation of EM Field. Plane Wave Solutions. Complex formulation Free propagation of EM waves in vacuum and in dielectric media	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
13	24				NO	NO	- Proposed exercises solving - Exposition of projects - Participation in discussions and debates	1,5	
13	25	Wave parameters: amplitude, spatial and temporal frequency, wavelength, period, propagation speed, refractive index Power and Intensity of EM waves. The Poynting's Vector Propagation in conducting media. Penetration depth	X		NO	NO	-Reading of the corresponding chapters in the proposed literature - Study and personal work on the lecture	1,5	
13	26				NO	NO	- Completion of specific exercises. - Work discussion and development of problems. - Participating in discussions and debates.	1,5	
14	27	**11. Introduction to Wave Optics** The electromagnetic spectrum. Properties Addition of simple waves. Beats. Phase and group velocity. Propagation in dielectric media. Light-matter interaction. Linear scattering. Wave phenomena: Polarization, Interference, Diffraction. Propagation in absorbing media	X		NO	NO	- Reading of proposed themes. - Individual work about the concepts, including bibliographic references.	1,5	
14	28				NO	NO	**- Test.** Delivery of work for continuous evaluation of Magnetostatics Time Dependent EM Fields	1,5	
SUBTOTAL								**42 + 56 = 98**	
15		Tutorial sessions, recoveries, project deliveries…					- Work delivery, extra test and recovery of	3	5

						classes		
16-18		Grading					3	21
TOTAL							**54**	**+ 92 = 146**

(*) Total of sessions with 2 lectures and/or experimental labs will be 4.

COMPLEMENTARY TEACHING WEEKLY PROGRAMMING *									
WEEK	**SESSION**	**DESCRIPTION**	**GRUP**		Space necessary other than classroom	YES/NO 2 lecturers session (*)	**WEEKLY PROGRAMMING FOR THE STUDENT**		
			BIG	**SMALL**			**DESCRIPTION**	**PRESENTIAL HOURS**	**HOMEWORK HOURS MAXIMUM 7 H**
1	1	Discussion on a specific topic based on its cutting-edge interest, special difficulty, teaching issues or those proposed by students.	X			NO	- Reading of proposed themes. - Individual work about the concepts, including bibliographic references.	1,5	5
1	2		X			NO		1,5	
2	3		X			NO		1,5	5
2	4		X			NO		1,5	
TOTAL								6+10 = 16	

*In EPS, 6 hours of complementary teaching will be given.