



## Teaching Guide

Identifying Data					2024/25
Subject (*)	High-voltage electrical installations	Code	770G02027		
Study programme	Grao en Enxeñaría Eléctrica				
Descriptors					
Cycle	Period	Year	Type	Credits	
Graduate	2nd four-month period	Third	Obligatory	6	
Language	SpanishGalician				
Teaching method	Face-to-face				
Prerequisites					
Department	Enxeñaría Industrial				
Coordinador	Méndez Sanmartín, Cristian	E-mail	cristian.mendez@udc.es		
Lecturers	Méndez Sanmartín, Cristian	E-mail	cristian.mendez@udc.es		
Web					
General description	Instalacións Eléctricas de Media e Alta Tensión: Elementos constituyentes. Subestaciones e Aparamenta. Cálculo de Cortocircuitos simétricos e asimétricos. Tratamento do Neutro. Tensión de Restablecemento. Sobretensións e Coordinación de Illamento. Protección eléctrica. Instalacións de posta a terra.				

## Study programme competences / results

Code	Study programme competences / results
A1	Capacidade para a redacción, firma, desenvolvemento e dirección de proxectos no ámbito da enxeñaría industrial, e en concreto da especialidade de electricidade.
A4	Capacidade de xestión da información, manexo e aplicación das especificacións técnicas e da lexislación necesarias no exercicio da profesión.
A5	Capacidade para analizar e valorar o impacto social e medioambiental das solucións técnicas actuando con ética, responsabilidade profesional e compromiso social, e buscando sempre a calidade e mellora continua.
A26	Capacidade para o cálculo e deseño de instalacións eléctricas de baixa e media tensión.
A27	Capacidade para o cálculo e deseño de instalacións eléctricas de alta tensión.
B1	Capacidade de resolver problemas con iniciativa, toma de decisións, creatividade e razoamento crítico.
B2	Capacidade de comunicar e transmitir coñecementos, habilidades e destrezas no campo da enxeñaría industrial.
B3	Capacidade de traballar nun contorno multilingüe e multidisciplinar.
B4	Capacidade de traballar e aprender de forma autónoma e con iniciativa.
B5	Capacidade para empregar as técnicas, habilidades e ferramentas da enxeñaría necesarias para a práctica desta.
B9	CB2 - Que los estudiantes sepan aplicar sus conocimientos a su trabajo o vocación de una forma profesional y posean las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio.
C3	Utilizar as ferramentas básicas das tecnoloxías da información e as comunicacións (TIC) necesarias para o exercicio da súa profesión e para a aprendizaxe ao longo da súa vida.

## Learning outcomes

Learning outcomes	Study programme competences / results



Identifies, classifies and describes electrical installations in BT, MT and AT.	A1	B1	C3
Calculates and designs electrical installations in MT and AT.	A4	B2	
Know and select the characteristics of materials, cables, switchgear and measurement equipment used in MV and AT electrical installations.	A5	B3	
Understands, selects and properly uses electrical protection techniques.	A26	B4	
Select and use appropriate tools for the design of electrical installations in MV and AT.	A27	B5	
Know and use the specific legislation and regulations of MT and AT electrical installations.		B9	
Select and understand the use of technical literature and other sources of information in Spanish and English.			

Contents	
Topic	Sub-topic
Summary according to the degree report	<p>Medium and high voltage installations. Switchgear</p> <p>Electrical substations and transformation centers. General characteristics. Protections.</p> <p>Elements and basic strategies for the protection of electrical systems.</p> <p>Protection of fundamental elements of electric power systems. Surges and protection.</p> <p>Introduction to insulation coordination.</p> <p>Quality of service and electricity supply.</p>
General Overview of Electric Power Systems	<p>Introduction to the analysis of electrical energy systems.</p> <p>Elements in electrical energy systems.</p> <ul style="list-style-type: none"> <li>- Electric power transmission lines.</li> <li>- Power transformers</li> <li>- Asynchronous and synchronous machines.</li> <li>- Substations. Busbar configuration and operations.</li> </ul> <p>Modelling of electrical elements (quadripoles).</p> <ul style="list-style-type: none"> <li>- Impedance parameters.</li> <li>- Admittance parameters.</li> <li>- Hybrid and inverse hybrid parameters.</li> <li>- Inverse transmission and transmission parameters.</li> <li>- Parameter conversion</li> <li>- Quadripole connection</li> </ul>
Load Flow Analysis	<p>Introduction to the unit system.</p> <p>Kennelly's Theorem</p> <p>Load flows.</p> <ul style="list-style-type: none"> <li>- Node classification, network state and Boucherot's theorem.</li> <li>- Node matrix equations for connection matrices.</li> <li>- Magnetic couplings</li> <li>- Node matrix equations by direct inspection of circuits.</li> <li>- Definition of node admittance matrix.</li> <li>- Calculation of node voltages and load flows.</li> <li>- Iterative resolution methods: Gauss-Seidel and Newton-Raphson.</li> </ul>



<p>Short-Circuit Analysis</p>	<p>Definition of node impedance matrix.</p> <ul style="list-style-type: none"><li>- Direct construction of node impedance matrix.</li><li>- Modification of network status.</li></ul> <p>Definition of short-circuit.</p> <ul style="list-style-type: none"><li>- Actuation of protective devices Power circuit breakers and disconnectors.</li><li>- Definition of transient and sub-transient regimes.</li></ul> <p>Calculation of symmetrical short circuits.</p> <ul style="list-style-type: none"><li>- Three-phase short-circuit of a no-load synchronous machine.</li><li>- Three-phase short-circuit of a no-load line.</li></ul> <p>Symmetrical components (Fortescue-Stokvis theorem)</p> <ul style="list-style-type: none"><li>- Direct component</li><li>- Inverse component</li><li>- Homopolar component (connection groups).</li></ul> <p>Calculation of asymmetrical short circuits.</p> <ul style="list-style-type: none"><li>- Phase-to-earth short-circuit</li><li>- Phase-to-phase short-circuit</li><li>- Phase-to-phase-to-earth short-circuit</li><li>- Lack of open conductor</li></ul>
<p>Electric Arc</p>	<p>Physical foundations.</p> <p>Static arc characteristic in direct current.</p> <p>Interruption of the arc in direct current.</p> <p>Interruption of the arc in alternating current.</p>
<p>Protection of Power Systems</p>	<p>Characteristics and functions of a protection system.</p> <p>Voltage and current transformers.</p> <p>relays. Characteristics.</p> <p>Overcurrent relays.</p> <p>Timed overcurrent relays.</p> <p>Relays with two inputs. General formula for activating a relay.</p> <p>Sequence filters.</p> <p>Bar protection.</p> <p>Transformer protection.</p> <p>Protection of generators and motors.</p> <p>Line protection.</p> <p>Overcurrent protection in radial lines</p> <p>Directional relays.</p> <p>Distance relays (impedance).</p> <p>Modified impedance relays.</p> <p>Relay response to unbalanced faults.</p>
<p>Grounding Installations</p>	<p>Definitions. Electrodes and ground lines.</p> <p>Step and touch voltages.</p> <p>Distributions of potential and grounding resistance of basic electrodes.</p> <p>Calculations with multi-electrode systems.</p>
<p>Neutral Treatment in Power Systems</p>	<p>Definitions.</p> <p>Study of the single-phase fault in a network with isolated neutral.</p> <p>Study of the single-phase fault in a network with extinguishing coil.</p> <p>Study of the single-phase fault in a network with the neutral grounded.</p> <p>Definition of the grounding coefficient.</p>



Transient Recovery Voltage (TRV)	<p>Study of the TRV by the current injection method.</p> <p>Calculation of the TRV for a short circuit in the generator terminals.</p> <p>Calculation of the TRV for a kilometer fault.</p> <p>Calculation of the TRV for a fault on the line.</p> <p>First pole factor.</p>
Overvoltage and Insulation Coordination	<p>Types and origin of surges.</p> <p>Traveling waves and surge propagation.</p> <p>Bewley's method for calculating overvoltages.</p> <p>Generation of surges in transmission lines.</p> <p>Direct and indirect downloads.</p> <p>Behavior of lines against lightning.</p> <p>Protection of lines against lightning.</p> <p>Lightning rod. Types and behavior of lightning rods.</p> <p>Isolation Coordination.</p> <p>Basic level of impulse isolation.</p> <p>Standardized test waves for the study of overvoltages.</p> <p>Voltage-time characteristic.</p>

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student's personal work hours	Total hours
Guest lecture / keynote speech	A26 A27 B3 C3	21	0	21
Problem solving	A27 A26 B1 B4 B5 B9 C3	16.5	0	16.5
Laboratory practice	A26 A27 B1 B3 B4 B5 B9 C3	9	0	9
Objective test	B1 B5	4	0	4
Student portfolio	A1 A4 A5 A26 A27 B1 B2 B3 B4 B5 B9 C3	0	90	90
Events academic / information	A1 A4 A5 A26 A27 B1 B2 B3 B4 B5 B9 C3	4.5	0	4.5
Personalized attention		5	0	5

(\*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
Methodologies	Description
Guest lecture / keynote speech	<p>Introductory session to the subject.</p> <p>Explanation of content by the teacher.</p>
Problem solving	Students solve calculation problems proposed by the teacher.
Laboratory practice	<p>Depending on availability / Not confirmed:</p> <p>-----</p> <p>Practices where the students are in charge of carrying out assemblies in the workshop where, according to the practice scripts of the subject, the indicated tests are carried out.</p> <p>If it is not possible to allocate this bag of hours to practices, they will be reused in the master session and problem solving.</p>
Objective test	Answer to questions or solve exercises without means of consultation or with restricted means of consultation, in a specific limited space of time.



Student portfolio	<p>Autonomous work: Study and development of skills related to the subject through the development of material or proposals discussed in the master session.</p> <p>Seminars: Presentation of specific topics related to the subject and discussion about them.</p> <p>Activities that can be carried out during the school period: In the case of a proposal by the teacher, a series of recoverable intermediate tests and supervised work could be carried out following the teacher's instructions.</p>
Events academic / information	<p>Depending on availability / Not confirmed: -----</p> <p>Events of a scientific and/or informative nature. Lectures or invited classes given by experts or by collaborating companies related to the competencies of each subject. Visits to industrial facilities related to the competences of each subject.</p> <p>If it is not possible to allocate this bag of hours to practices, they will be reused in the master session and problem solving.</p>

### Personalized attention

Methodologies	Description
Problem solving Student portfolio Guest lecture / keynote speech	The teacher responds individually or in a group to questions or queries made by students.

### Assessment

Methodologies	Competencies / Results	Description	Qualification
Problem solving	A27 A26 B1 B4 B5 B9 C3	20% of the evaluation of this section will be included in the case of carrying out an intermediate test if that were the case. If this were not the case, this percentage would be added to the objective test.	20
Student portfolio	A1 A4 A5 A26 A27 B1 B2 B3 B4 B5 B9 C3	A 20% valuation of this section will be included in the case of carrying out some supervised work if the case arises. If this were not the case, this percentage would be added to the objective test.	20
Objective test	B1 B5	<p>In the correction of objective tests, the following factors may be taken into account, among other things:</p> <ul style="list-style-type: none"> <li>- The follow-up of the instructions for its realization.</li> <li>- The technical correctness of the calculations and results.</li> <li>- The order, cleanliness and organization of the delivered material.</li> <li>- The correct expression of the ideas and reasoning used.</li> </ul>	60

### Assessment comments



The evaluation of the subject will be carried out through the following tests:

Activities that can be carried out during the school period:

It may be proposed to carry out intermediate tests with a value of up to 20% of the total value of the subject grade (in the case of the proposed carrying out of these, this score may be recoverable through the final objective test). It may be proposed to carry out supervised work with a value of up to 20% of the total value of the subject grade (in the case of the proposed carrying out of these scores it will not be recoverable). Final objective test:

Completion of this objective test will be mandatory in order to pass the subject, 40% of the test must be presented and passed correctly in order to add up the score for the activities that can be carried out during the academic period. Depending on the organization or not of the activities during the academic period, the evaluation of the punctuation of the same would be added to the final percentage of the final objective test, which could vary between 60% and 100% of the weighting of the final grade, being necessary to exceed 50% of the test to pass the subject. The assessment method will be similar for the first and second opportunities. Note on the assessment of non-face-to-face activities:

Non-face-to-face activities:

The teacher will reserve the right to request additional information by video conference in order to validate the veracity of the authorship of the content presented, reserving the right to a reduction of up to 100% of the score obtained in the case of inconclusive answers that may present doubts about the work done .

Additional conditions:

Condition of not presented:

Students who do not present themselves for the first or second opportunity objective test will obtain the status of not presented, regardless of the evaluation of the possible activities carried out during the academic period.

Early call:

Students who make an early call may retain the score obtained in the activities carried out during the academic period during a call. After this, if the subject has not been passed or no test has been taken, they will be evaluated through a final objective test, scoring it at 100% of the subject's grade, and it is necessary to pass 50% of the test to pass the subject.

Academic exemption:

Students with an academic dispensation will be exempt from class attendance and laboratory practices. The evaluation methods will be equivalent to those used with students enrolled in the face-to-face mode.

Fraudulent performance:

Students who fraudulently carry out any type of assessment activity (whether carrying out activities during the academic period or in the objective test), once verified, will automatically be classified as failed (numerical grade 0) in the corresponding call for the academic year, and may not evaluate the subject until the next call for the next academic year.

## Sources of information

<b>Basic</b>	<ul style="list-style-type: none"> <li>- Kothari D. P., Nagrath I. J. (2008). Modern Power System Analysis. McGraw Hill</li> <li>- Grainger J. J., Stevenson W. D. (1996). Análisis de Sistemas de Potencia. McGraw Hill</li> <li>- Saadat H. (2011). Power System Analysis. PSA Publishing LLC</li> <li>- Suárez Creo, Juan M., Andavira (2011). Protección de Instalaciones y Redes Eléctricas. Andavira</li> <li>- Bergen A.R., Vittal V. (1986). Power System Analysis. Prentice-Hall International</li> <li>- Gross C.A. (1986). Power System Analysis. Wiley</li> </ul>
<b>Complementary</b>	<ul style="list-style-type: none"> <li>- Simón Comín P., Garnacho Vecino F. et. Al (2011). Cálculo y diseño de líneas eléctricas de alta tensión. Ibergarceta</li> <li>- Glover, J. D., Sarma M.S., Overbye T. J. (2011). Power System Analysis and Design. Cengage Learning</li> <li>- Barrero F. (2004). Sistemas de Energía Eléctrica. Paraninfo</li> </ul>

## Recommendations

### Subjects that it is recommended to have taken before

Electric Installations low voltage/770G02022

Electrical power circuits/770G02023

Fundamentos de Electricidade/770G02013

Electric Machines/770G02121

### Subjects that are recommended to be taken simultaneously



Electric Machines and Drives/770G02126

Electric Energy Transport/770G02036

**Subjects that continue the syllabus**

**Other comments**

To help achieve an immediate sustainable environment and fulfill the objective of action number 5: "Teaching and research that is healthy and environmentally and socially sustainable" of the "Green Campus Ferrol Action Plan": The delivery of the documentary work carried out in this matter: 1.1. It will be requested in virtual format and/or computer support. 1.2. It will be done through Moodle, in digital format without the need to print them. 1.3. If done on paper: - Plastics will not be used - Double-sided printing will be carried out. - Recycled paper will be used. - The printing of drafts will be avoided. In addition to this, the full integration of students who, for physical, sensory, psychological or socio-cultural reasons, experience difficulties in having a suitable, equal and profitable access to university life will be facilitated.

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