




Language :	English
Place of the course	Autre site
Prerequisites	Courses in the following field <ul style="list-style-type: none"> <li>· Nuclear reactor theory</li> <li>· Nuclear thermal hydraulics</li> </ul>
Learning outcomes	<p><b>At the end of this learning unit, the student is able to :</b></p> <p><u>To introduce the students to methods and practices supporting the defense-in-depth approach for nuclear power plants.</u></p> <p><u>More specifically:</u></p> <ul style="list-style-type: none"> <li>• To present elements of nuclear safety philosophy.</li> <li>• To understand how to insure the link between nuclear safety and reactor operation.</li> </ul> <p>1</p> <ul style="list-style-type: none"> <li>• To master all the contributors to the core reactivity balance and power distribution in normal operation.</li> <li>• To understand specific measurement and control issues in nuclear reactors.</li> <li>• To introduce the basic notions and techniques of system reliability engineering.</li> <li>• To understand the concepts of safety analyses (both deterministic and probabilistic), and the fundamentals of probabilistic safety analysis (PSA).</li> <li>• To present some PSA-based applications.</li> </ul>
Evaluation methods	<p><u>Operation &amp; Control</u></p> <p>First and second session: Individual oral exam, closed book, written preparation</p> <p><u>Reliability &amp; Safety</u></p> <p>First and second session: An oral examination (closed book) with one question on the concepts and one exercise</p>
Content	<p><u>Operation &amp; Control (28h)</u></p> <ul style="list-style-type: none"> <li>• Cycle specific safety evaluation methodology.</li> <li>• Basic principles of the in-core fuel management based on the linear reactivity model.</li> <li>• Reactivity coefficients (moderator, Doppler), neutron poisons (xenon, samarium, I), their variation with burnup and core state parameters and their impact on core power distribution</li> <li>• Reactivity control means (boron, control rods, burnable poisons) and their sensitivity to the core burnup and in-core fuel management parameters.</li> <li>• Operating modes, operating limits and protection diagram.</li> <li>• Fuel rod design and thermal-mechanical behavior in normal operation and accidental conditions.</li> <li>• Thermal design procedures and elaboration of the core thermal limits and core protections.</li> <li>• Core control, surveillance and protection systems</li> </ul> <p><b>Optional</b> visits and laboratory session:</p> <ul style="list-style-type: none"> <li>• Visit of a Nuclear Power Plant.</li> <li>• Two day session of compact and full scope Nuclear Power Plant simulator.</li> </ul> <p>Seminars: Overview of design basis accidents and severe accidents; Discussion of selected past nuclear (severe) accidents (TMI, Chernobyl, Fukushima-Daiichi...)</p> <p><u>Reliability &amp; Safety (14h theory + 6h exercises)</u></p> <ul style="list-style-type: none"> <li>• Introduction to nuclear safety and defence in depth</li> <li>• concept of risk, individual and societal risk criteria, release limits, core damage frequency limit, safety goals at function or system level</li> <li>• deterministic vs. probabilistic safety analyses;</li> <li>• probabilistic safety assessment (PSA) methodology and PSA levels</li> <li>• Component reliability</li> <li>• Fault tree and event tree analysis</li> <li>• Markov analysis</li> <li>• Common cause failure analysis</li> <li>• Elements of human reliability analysis</li> <li>• Elements of the level 2 and level 3 PSA methodology</li> <li>• Limits of the classical PSA methodology</li> </ul>

	<ul style="list-style-type: none"> <li>• PSA-based applications</li> </ul>
Inline resources	<a href="https://www.sckcen.be/fbnen">https://www.sckcen.be/fbnen</a>
Other infos	<p>Course location: SCK-Cen (Mol)</p> <p><b>Prof. Greet Janssens-Maenhout</b> -Universiteit Gent</p> <p>NN - Universiteit Gent</p> <p><b>Prof. Pierre- Etienne Labeau</b> -Université Libre de Bruxelles</p>
Faculty or entity in charge	EPL

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Mechanical Engineering	MECA2M	5		
Advanced Master in Nuclear Engineering	GNUC2MC	5		
Master [120] in Electro-mechanical Engineering	ELME2M	5		
Master [120] in Energy Engineering	NRGY2M	5		